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Kumar et al.

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(54) **DYNAMIC ADDITIONAL DEMODULATION REFERENCE SIGNAL CONFIGURATION**

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(73) Assignee: **DELL PRODUCTS L.P.**, Round Rock, TX (US)

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(51) **Int. Cl.**
H04L 5/00 (2006.01)
H04L 1/1812 (2023.01)

(52) **U.S. Cl.**
CPC ***H04L 5/0051*** (2013.01); ***H04L 1/1812*** (2013.01); ***H04L 5/0098*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 5/003; H04L 5/0048; H04L 5/0051; H04L 1/18; H04L 1/1812; H04L 5/0091; H04L 5/0096; H04L 5/0098; H04L 27/261; H04L 2025/03783; H04L 2025/03796; H04L 47/365; H04L 47/76; H04L 47/762; H04W 4/20; H04W 28/00; H04W 72/231
See application file for complete search history.

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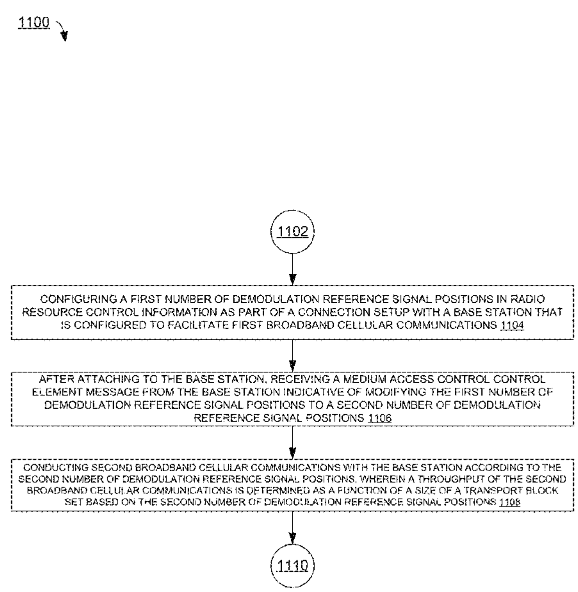
(57) **ABSTRACT**

A system can configure a first number of demodulation reference signal positions in radio resource control information as part of a connection setup with a base station that is configured to facilitate first broadband cellular communications. The system can, after attaching to the base station, receive a medium access control control element message from the base station indicative of modifying the first number of demodulation reference signal positions to a second number of demodulation reference signal positions. The system can conduct second broadband cellular communications with the base station according to the second number of demodulation reference signal positions, wherein a throughput of the second broadband cellular communications is determined as a function of a size of a transport block set based on the second number of demodulation reference signal positions.

20 Claims, 20 Drawing Sheets



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Kumar, Sunil. “Dynamic Additional Demodulation Reference Signal Configuration” U.S. Appl. No. 18/063,357, filed Dec. 8, 2022, 73 pages.

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Notice of Allowance mailed May 5, 2025 for U.S. Appl. No. 18/068,737, 40 pages.

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100

```
-- ASN1START
-- TAG-DMRS-DOWNLINKCONFIG-START

DMRS-DownlinkConfig ::=          SEQUENCE {
    dmrs-Type                        ENUMERATED {type2}                      OPTIONAL,   -- Need S
    dmrs-AdditionalPosition          ENUMERATED {pos0, pos1, pos3}           OPTIONAL,   -- Need S
    maxLength                        ENUMERATED {len2}                       OPTIONAL,   -- Need S
    scramblingID0                    INTEGER (0..65535)                      OPTIONAL,   -- Need S
    scramblingID1                    INTEGER (0..65535)                      OPTIONAL,   -- Need S
    phaseTrackingRS                  SetupRelease { PTRS-DownlinkConfig  } OPTIONAL,   -- Need M
    ...,
    [[
    dmrs-Downlink-r16              ENUMERATED {enabled}                    OPTIONAL    -- Need R
    ]]

}

-- TAG-DMRS-DOWNLINKCONFIG-STOP
-- ASN1STOP
```

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FIG. 1

200

```
-- ASN1START
-- TAG-DMRS-UPLINKCONFIG-START

DMRS-UplinkConfig ::=                SEQUENCE {
    dmrs-Type                            ENUMERATED {type2}                    OPTIONAL,   -- Need S
    dmrs-AdditionalPosition              ENUMERATED {pos0, pos1, pos3}         OPTIONAL,   -- Need S
    phaseTrackingRS                      SetupRelease { PTRS-UplinkConfig }    OPTIONAL,   -- Need M
    maxLength                            ENUMERATED {len2}                     OPTIONAL,   -- Need S
    transformPrecodingDisabled           SEQUENCE {
        scramblingID0                        INTEGER (0..65535)                OPTIONAL,   -- Need S
        scramblingID1                        INTEGER (0..65535)                OPTIONAL,   -- Need S
        ...,
        [[
        dmrs-Uplink-r16                      ENUMERATED {enabled}              OPTIONAL    -- Need R
        ]]
    }                                                                          OPTIONAL,   -- Need R

-- TAG-DMRS-UPINKCONFIG-STOP
-- ASN1STOP
```

202

FIG. 2

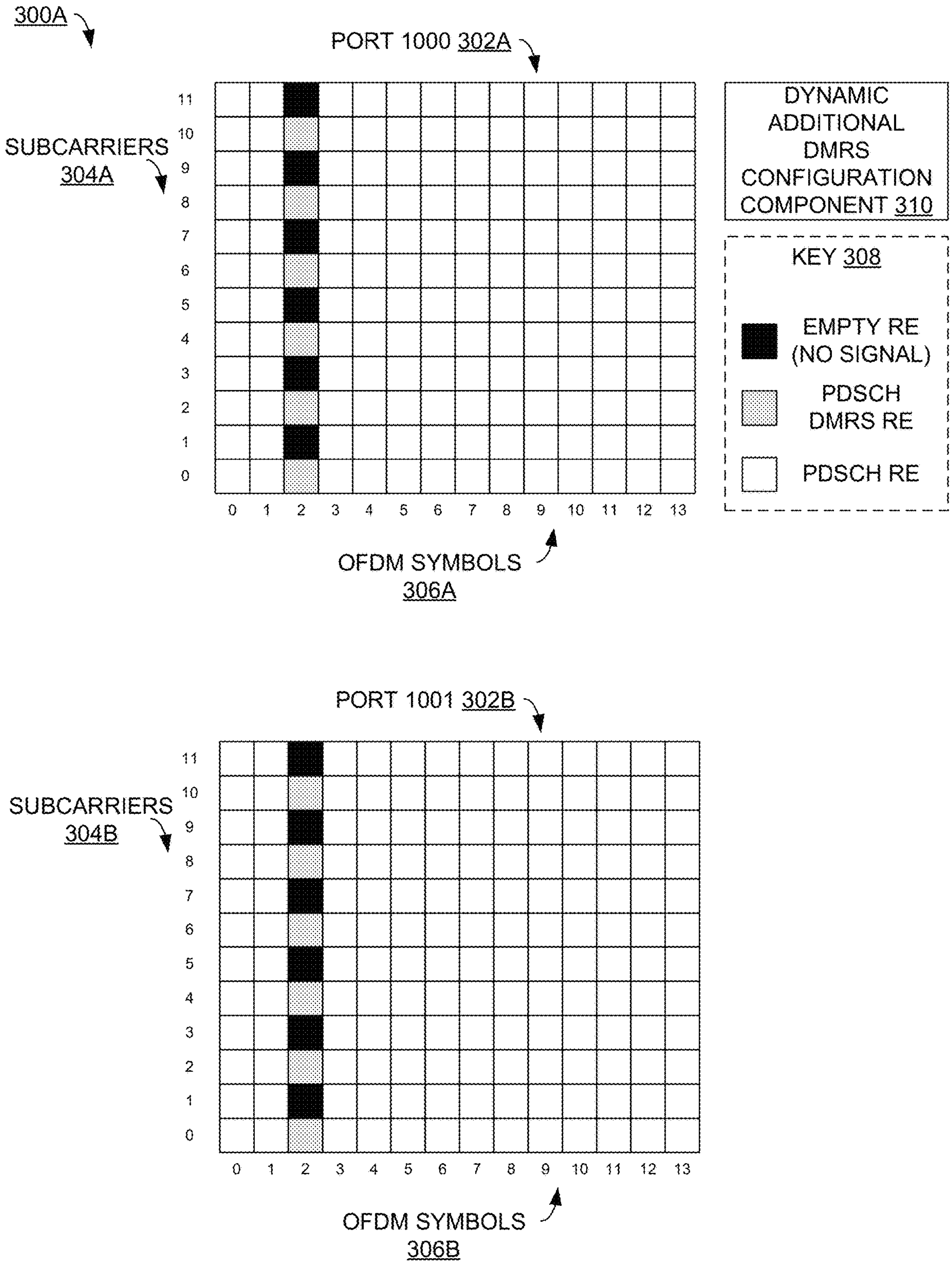

300A
PORT 1000 302A
SUBCARRIERS 304A
OFDM SYMBOLS 306A
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 310
KEY 308
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1001 302B
SUBCARRIERS 304B
OFDM SYMBOLS 306B

FIG. 3A

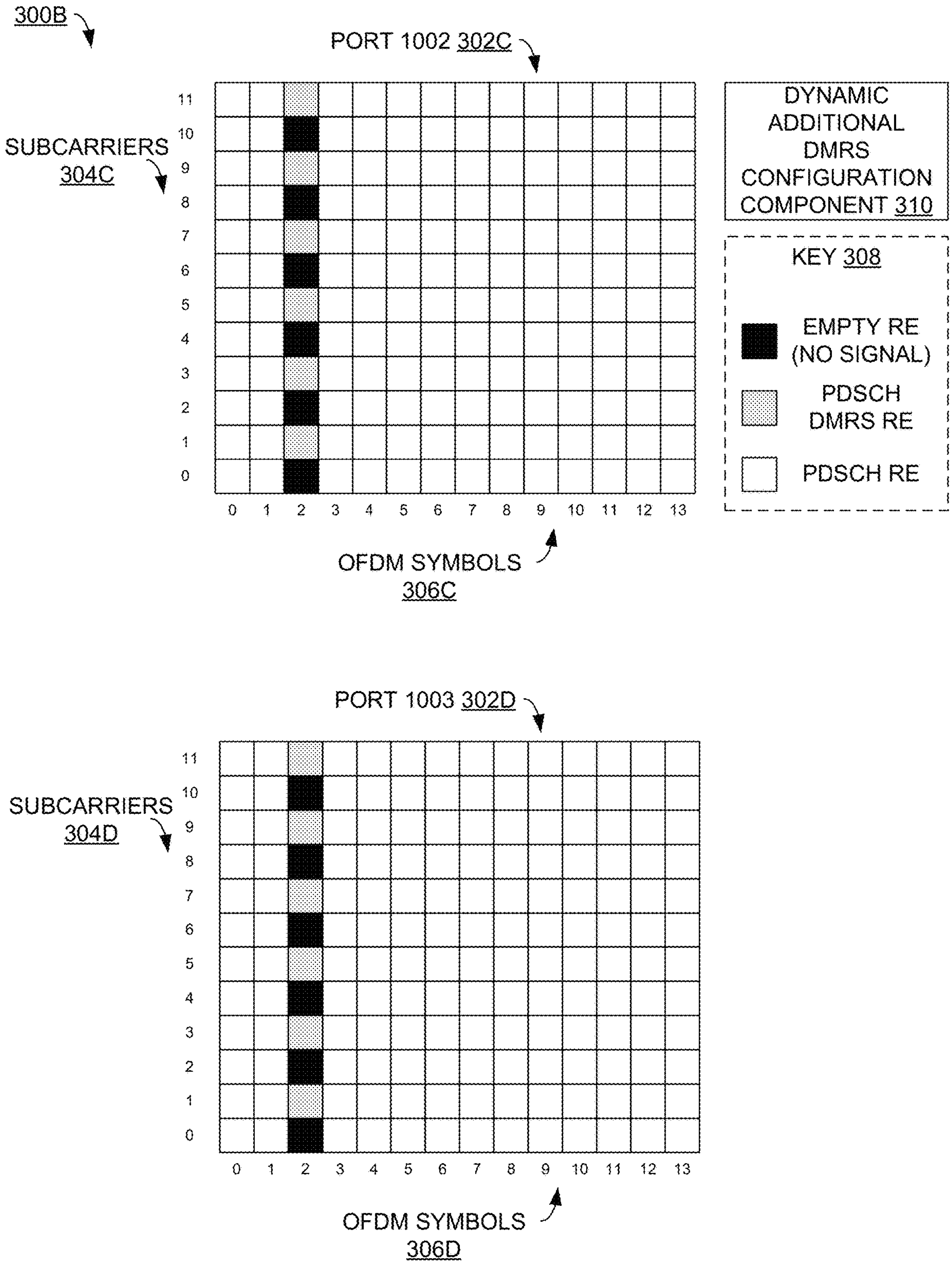

300B
PORT 1002 302C
SUBCARRIERS 304C
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
OFDM SYMBOLS 306C
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 310
KEY 308
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1003 302D
SUBCARRIERS 304D
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
OFDM SYMBOLS 306D

FIG. 3B

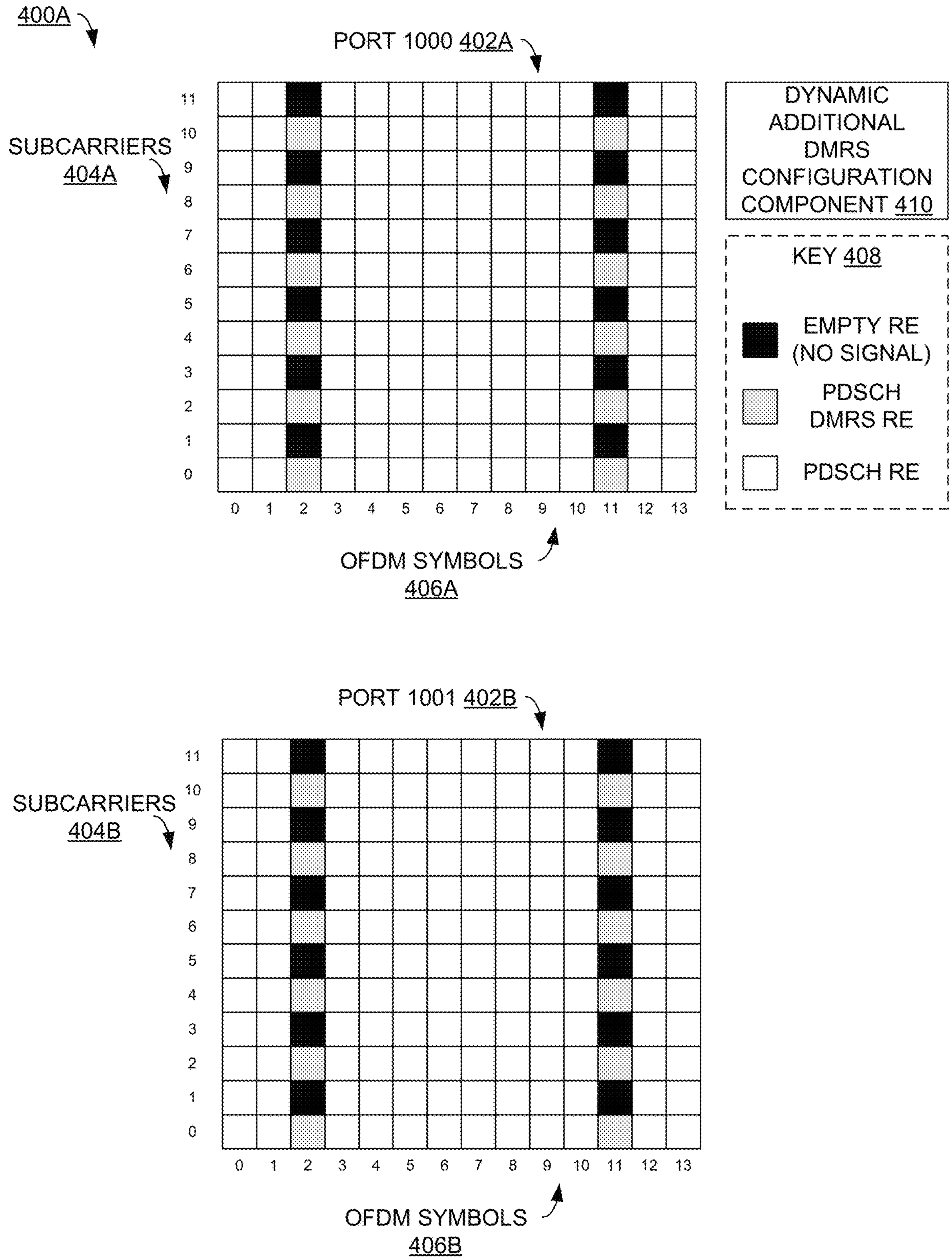

400A
PORT 1000 402A
SUBCARRIERS 404A
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
OFDM SYMBOLS 406A
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 410
KEY 408
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1001 402B
SUBCARRIERS 404B
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
OFDM SYMBOLS 406B

FIG. 4A

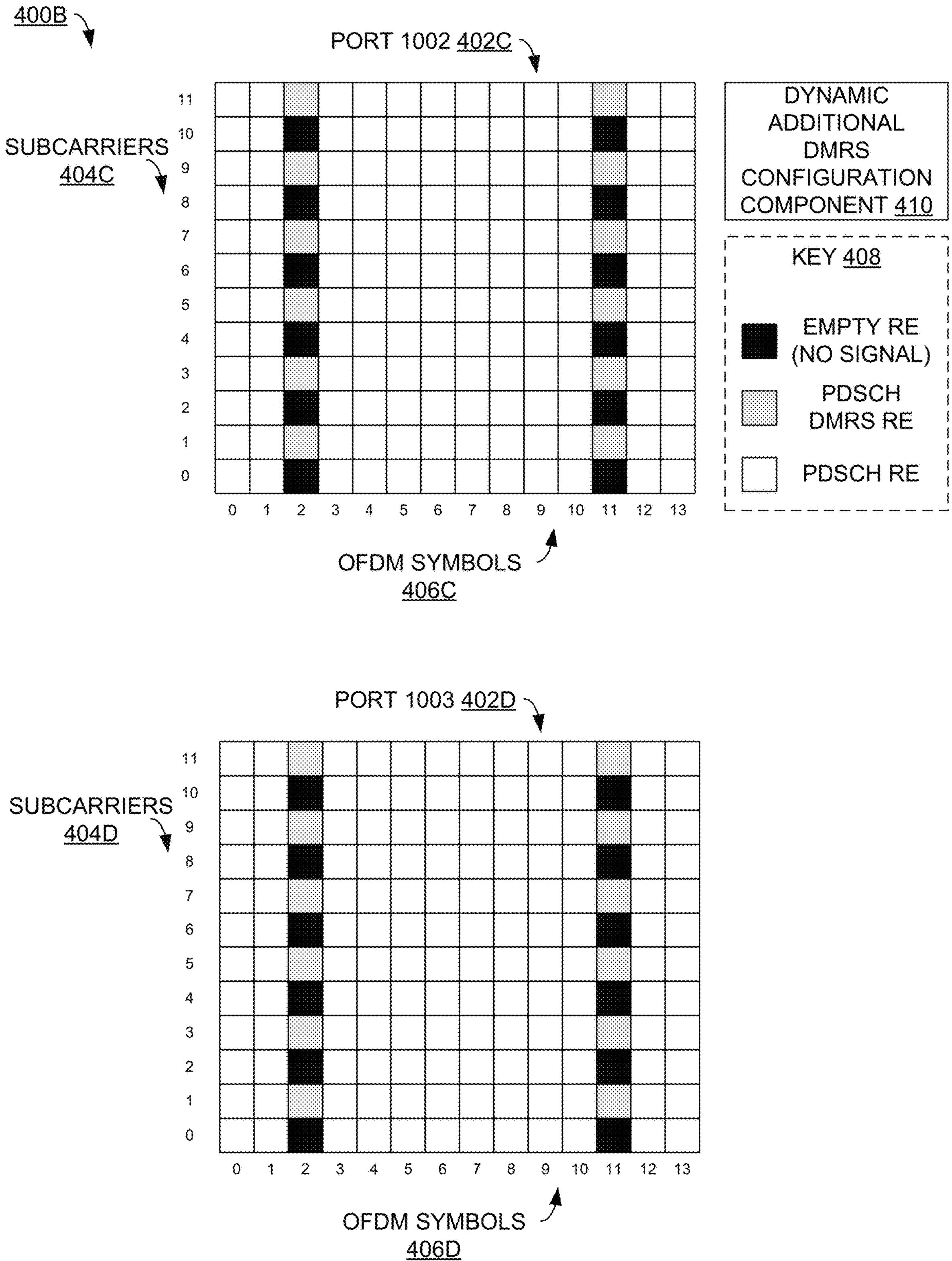

400B
PORT 1002 402C
SUBCARRIERS 404C
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
OFDM SYMBOLS 406C
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 410
KEY 408
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1003 402D
SUBCARRIERS 404D
11
10
9
8
7
6
5
4
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
OFDM SYMBOLS 406D

FIG. 4B

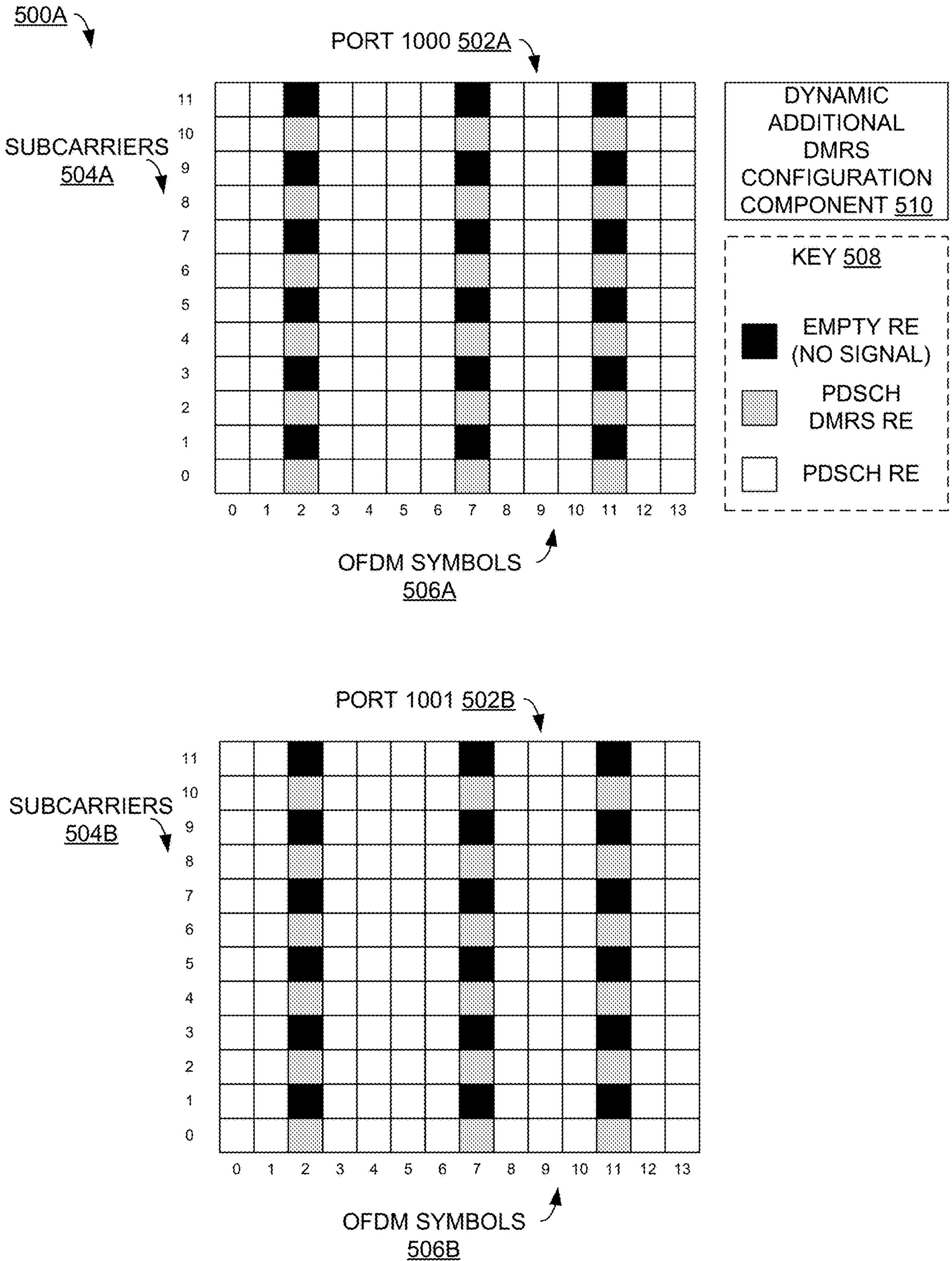

500A
PORT 1000 502A
SUBCARRIERS 504A
OFDM SYMBOLS 506A
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 510
KEY 508
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1001 502B
SUBCARRIERS 504B
OFDM SYMBOLS 506B
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6 7 8 9 10 11 12 13

FIG. 5A

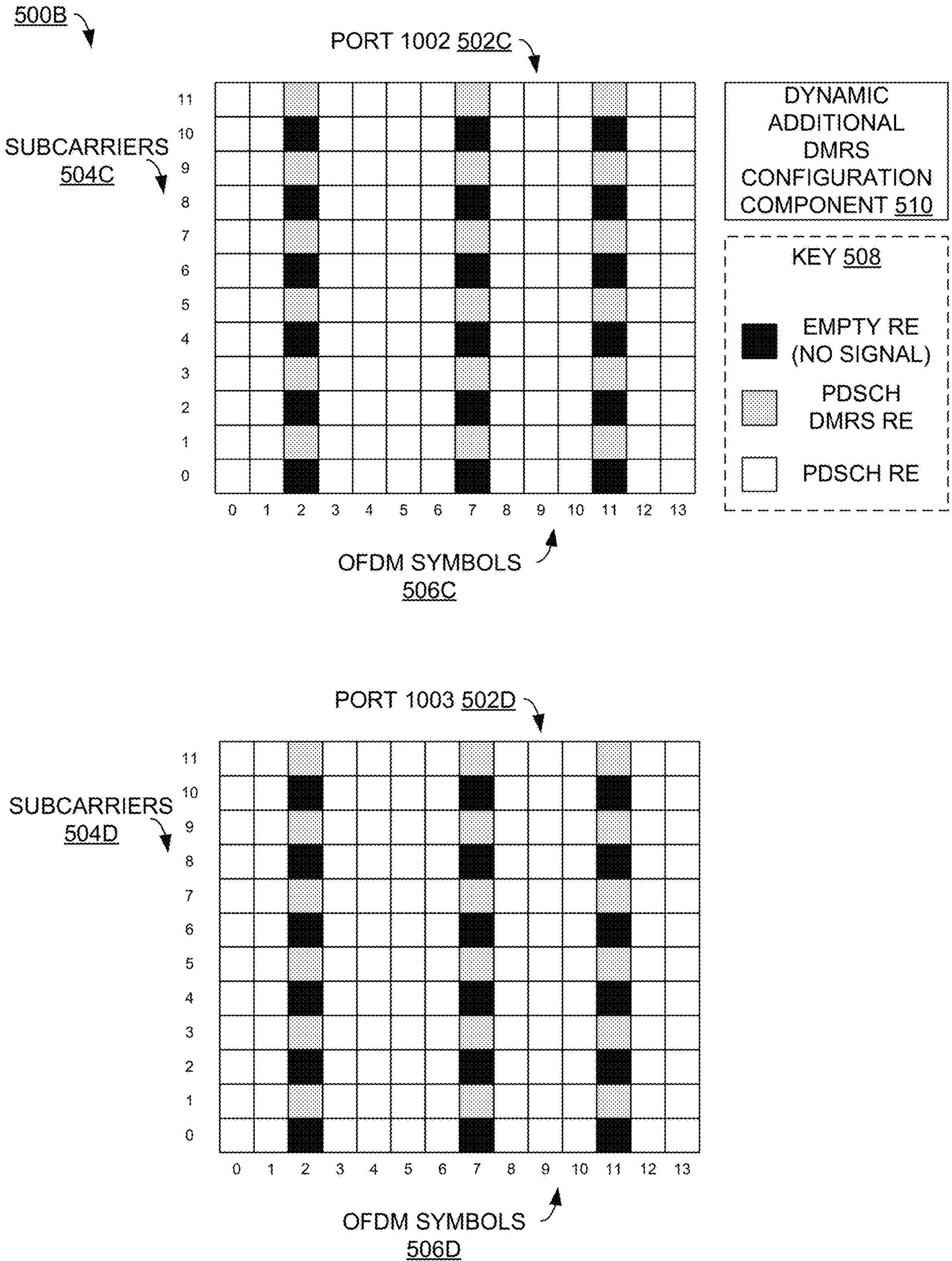

500B
PORT 1002 502C
SUBCARRIERS 504C
OFDM SYMBOLS 506C
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 510
KEY 508
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1003 502D
SUBCARRIERS 504D
OFDM SYMBOLS 506D

FIG. 5B

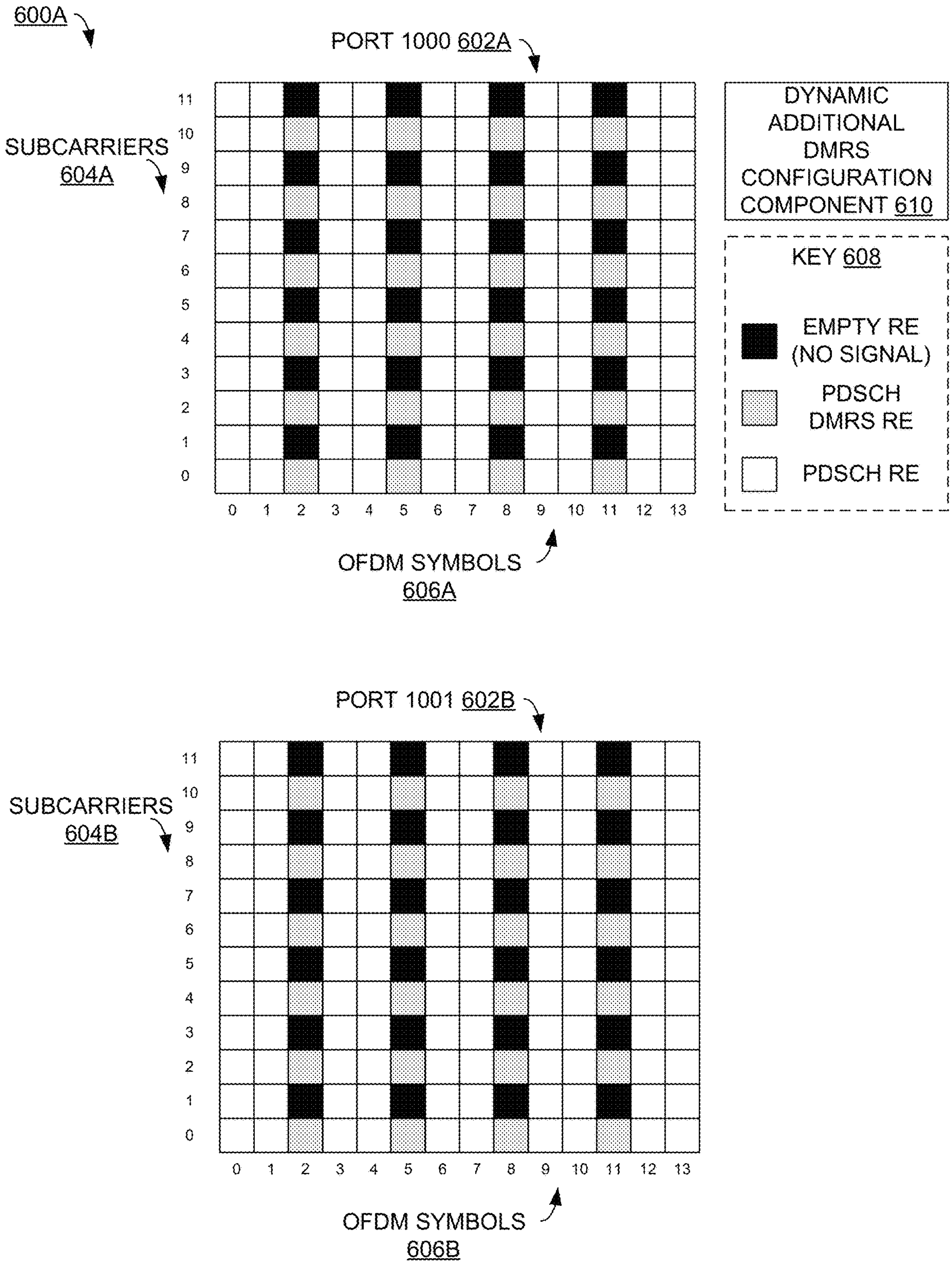

600A
PORT 1000 602A
SUBCARRIERS 604A
0 1 2 3 4 5 6 7 8 9 10 11
OFDM SYMBOLS 606A
0 1 2 3 4 5 6 7 8 9 10 11 12 13
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 610
KEY 608
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1001 602B
SUBCARRIERS 604B
0 1 2 3 4 5 6 7 8 9 10 11
OFDM SYMBOLS 606B
0 1 2 3 4 5 6 7 8 9 10 11 12 13

FIG. 6A

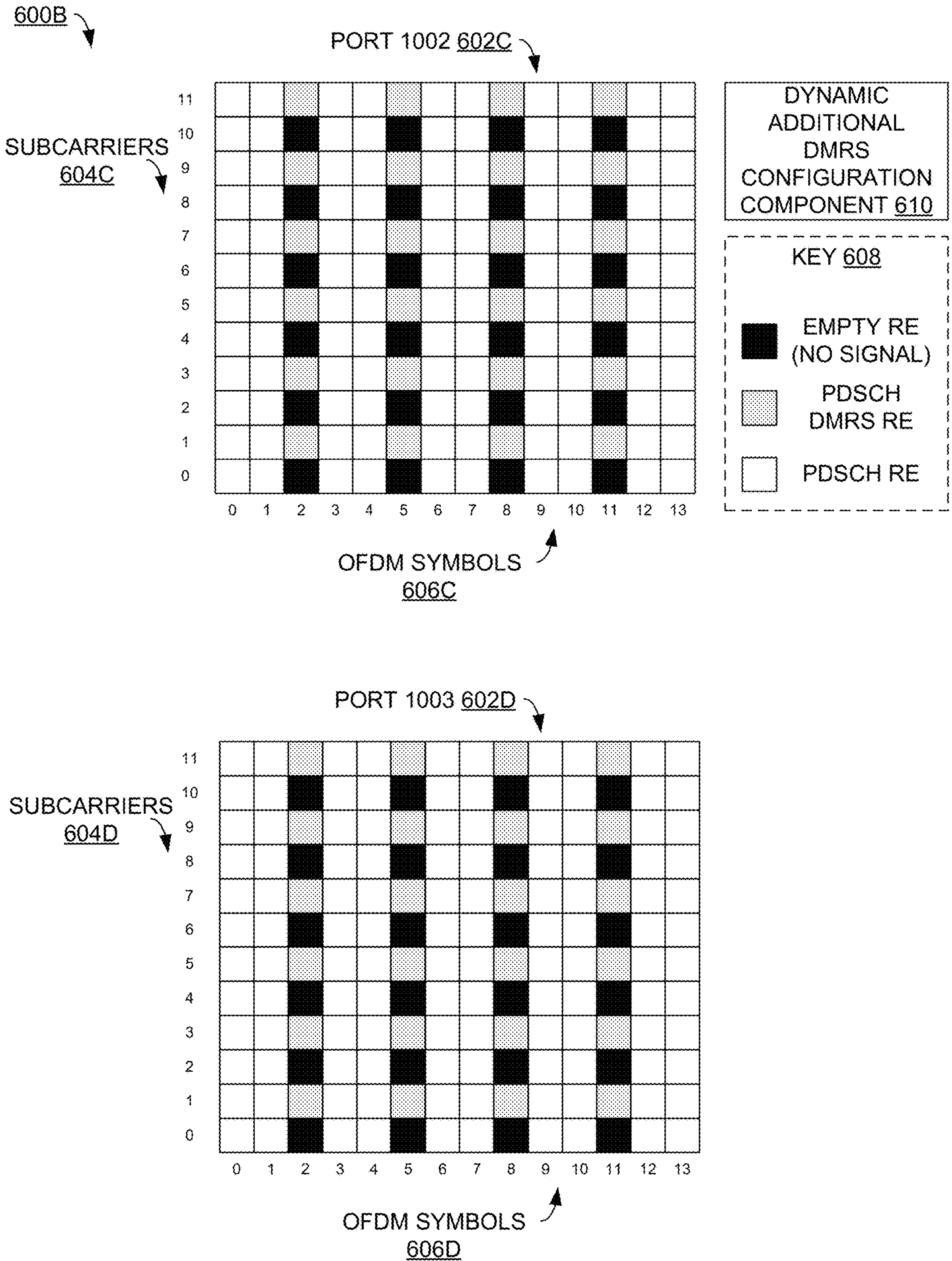

600B
PORT 1002 602C
SUBCARRIERS 604C
OFDM SYMBOLS 606C
DYNAMIC ADDITIONAL DMRS CONFIGURATION COMPONENT 610
KEY 608
EMPTY RE (NO SIGNAL)
PDSCH DMRS RE
PDSCH RE
PORT 1003 602D
SUBCARRIERS 604D
OFDM SYMBOLS 606D

FIG. 6B

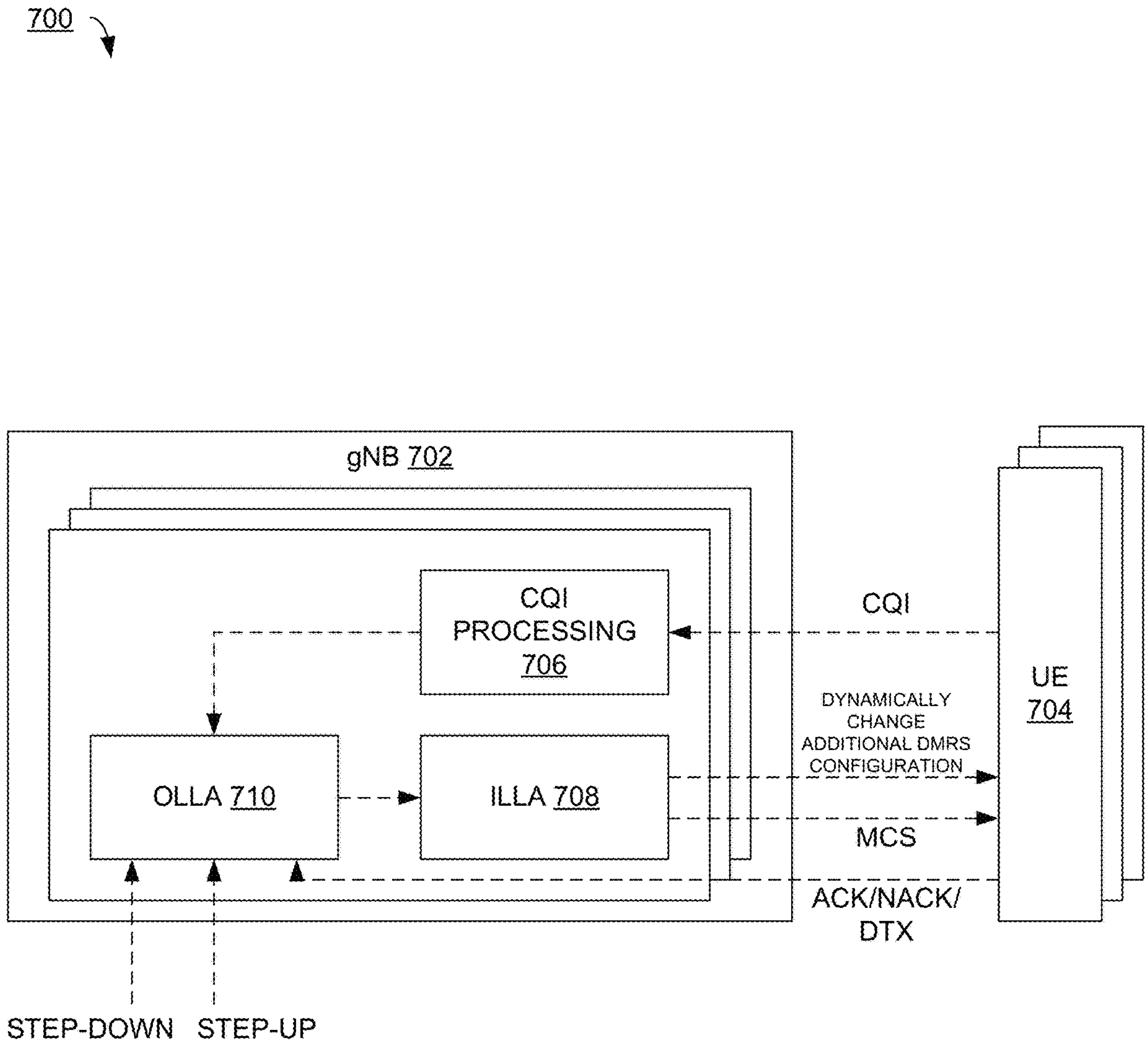
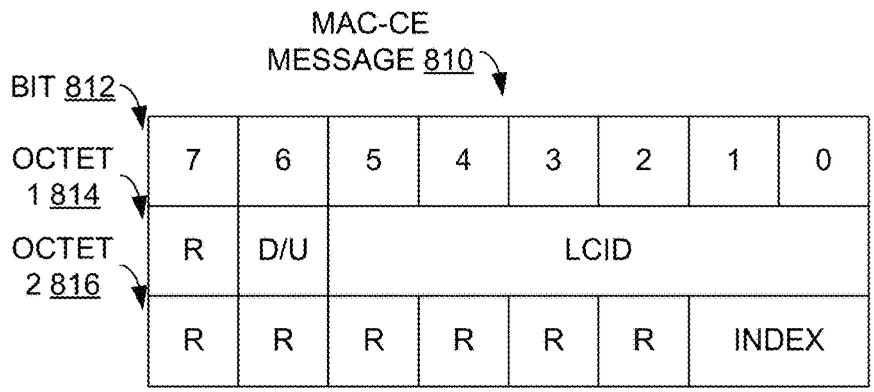

700
gNB 702
CQI PROCESSING 706
OLLA 710
ILLA 708
CQI
DYNAMICALLY CHANGE ADDITIONAL DMRS CONFIGURATION
MCS
ACK/NACK/ DTX
UE 704
STEP-DOWN
STEP-UP

FIG. 7

800



ADDITIONAL DMRS POSITION
INDICATION 820

INDEX 822	ADDITIONAL DRMS POSITION 824
0	POS0
1	POS1
2	POS2
3	POS3

FIG. 8

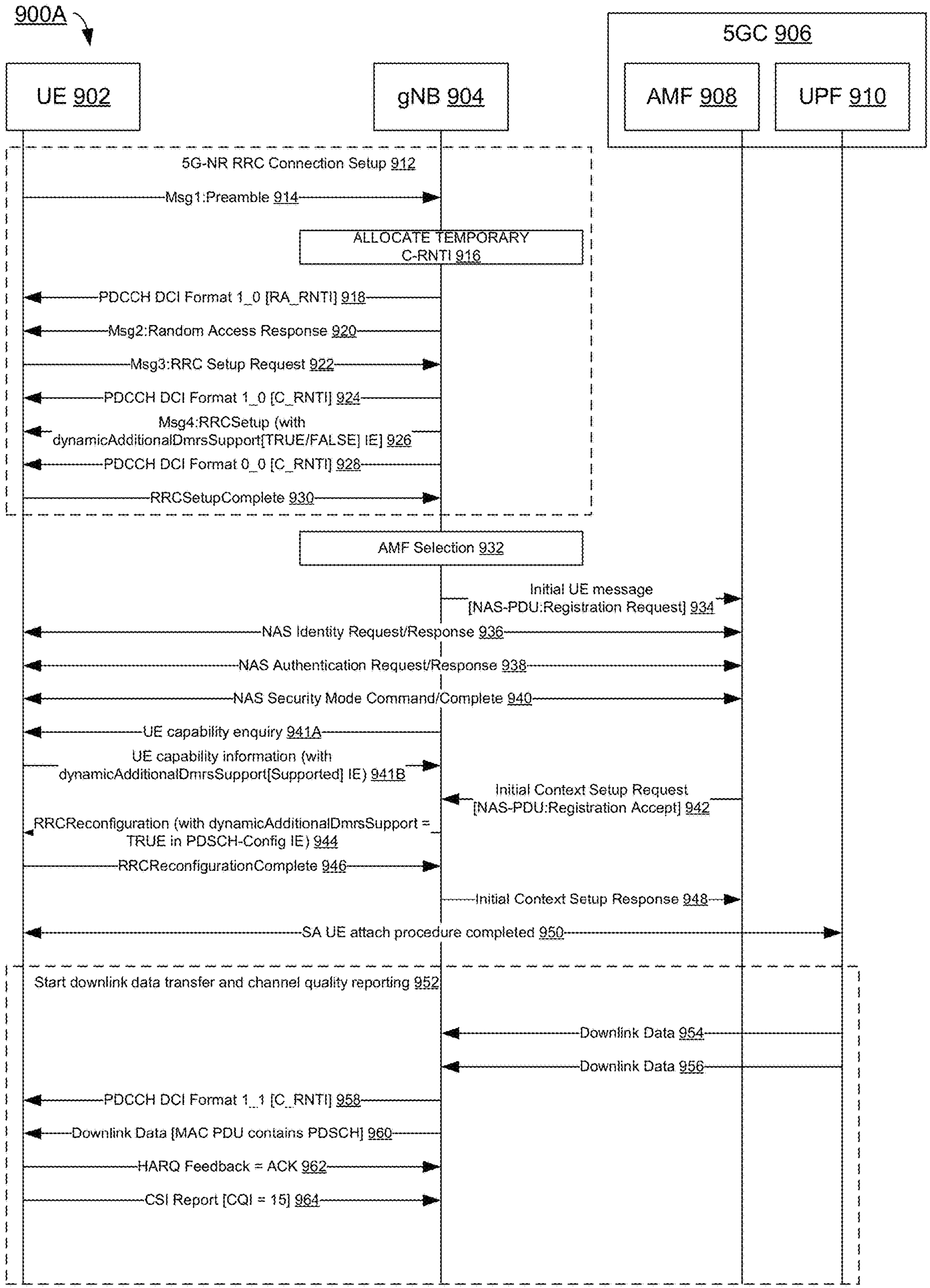

900A
5GC 906
UE 902
gNB 904
AMF 908
UPF 910
5G-NR RRC Connection Setup 912
Msg1:Preamble 914
ALLOCATE TEMPORARY C-RNTI 916
PDCCH DCI Format 1_0 [RA_RNTI] 918
Msg2:Random Access Response 920
Msg3:RRC Setup Request 922
PDCCH DCI Format 1_0 [C_RNTI] 924
Msg4:RRCSetup (with dynamicAdditionalDmrsSupport[TRUE/FALSE] IE] 926
PDCCH DCI Format 0_0 [C_RNTI] 928
RRCSetupComplete 930
AMF Selection 932
Initial UE message [NAS-PDU:Registration Request] 934
NAS Identity Request/Response 936
NAS Authentication Request/Response 938
NAS Security Mode Command/Complete 940
UE capability enquiry 941A
UE capability information (with dynamicAdditionalDmrsSupport[Supported] IE) 941B
Initial Context Setup Request [NAS-PDU:Registration Accept] 942
RRCReconfiguration (with dynamicAdditionalDmrsSupport = TRUE in PDSCH-Config IE) 944
RRCReconfigurationComplete 946
Initial Context Setup Response 948
SA UE attach procedure completed 950
Start downlink data transfer and channel quality reporting 952
Downlink Data 954
Downlink Data 956
PDCCH DCI Format 1_1 [C_RNTI] 958
Downlink Data [MAC PDU contains PDSCH] 960
HARQ Feedback = ACK 962
CSI Report [CQI = 15] 964

FIG. 9A

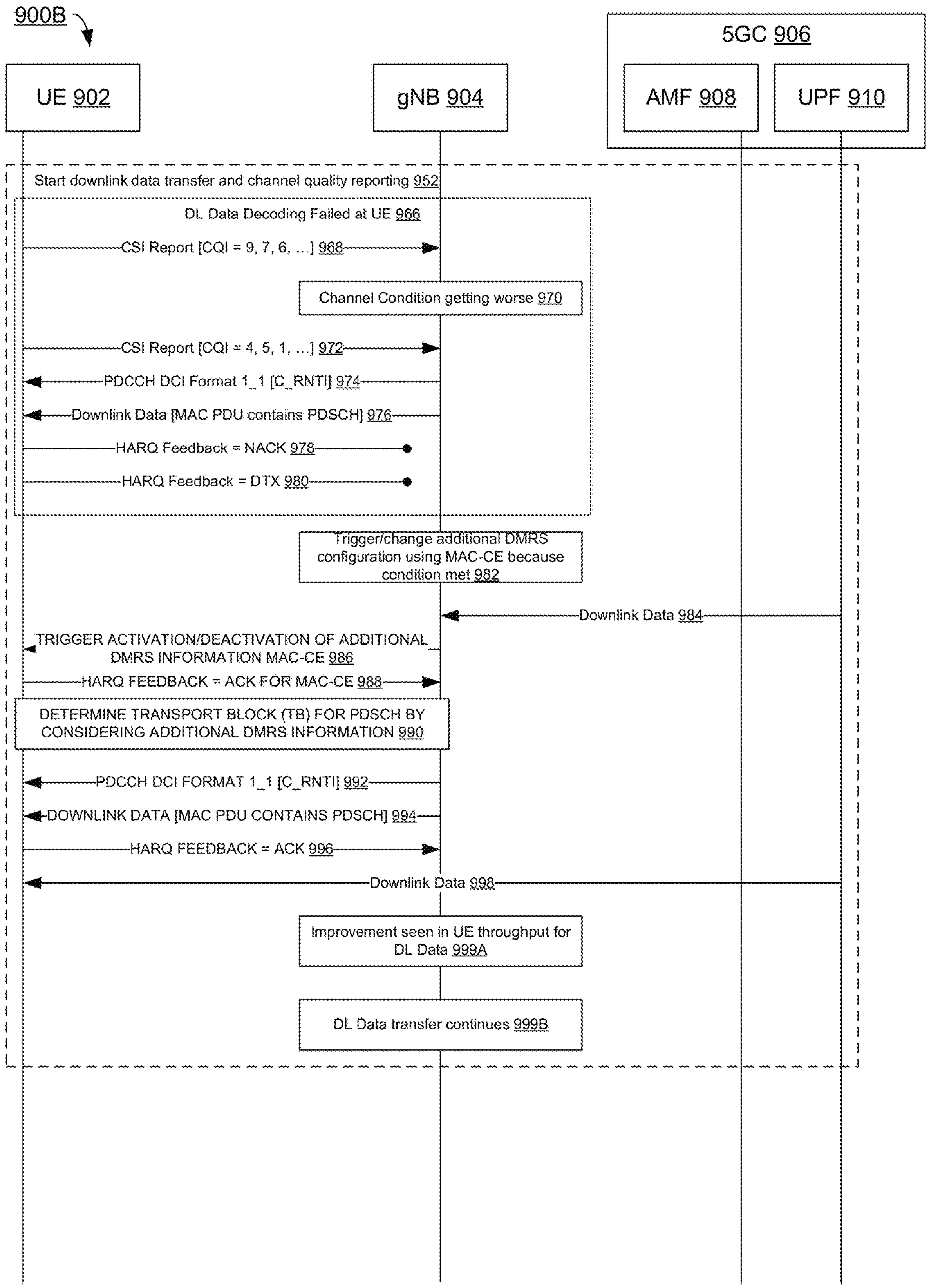

900B
5GC 906
UE 902
gNB 904
AMF 908
UPF 910
Start downlink data transfer and channel quality reporting 952
DL Data Decoding Failed at UE 966
CSI Report [CQI = 9, 7, 6, ...] 968
Channel Condition getting worse 970
CSI Report [CQI = 4, 5, 1, ...] 972
PDCCH DCI Format 1_1 [C_RNTI] 974
Downlink Data [MAC PDU contains PDSCH] 976
HARQ Feedback = NACK 978
HARQ Feedback = DTX 980
Trigger/change additional DMRS configuration using MAC-CE because condition met 982
Downlink Data 984
TRIGGER ACTIVATION/DEACTIVATION OF ADDITIONAL DMRS INFORMATION MAC-CE 986
HARQ FEEDBACK = ACK FOR MAC-CE 988
DETERMINE TRANSPORT BLOCK (TB) FOR PDSCH BY CONSIDERING ADDITIONAL DMRS INFORMATION 990
PDCCH DCI FORMAT 1_1 [C_RNTI] 992
DOWNLINK DATA [MAC PDU CONTAINS PDSCH] 994
HARQ FEEDBACK = ACK 996
Downlink Data 998
Improvement seen in UE throughput for DL Data 999A
DL Data transfer continues 999B

FIG. 9B

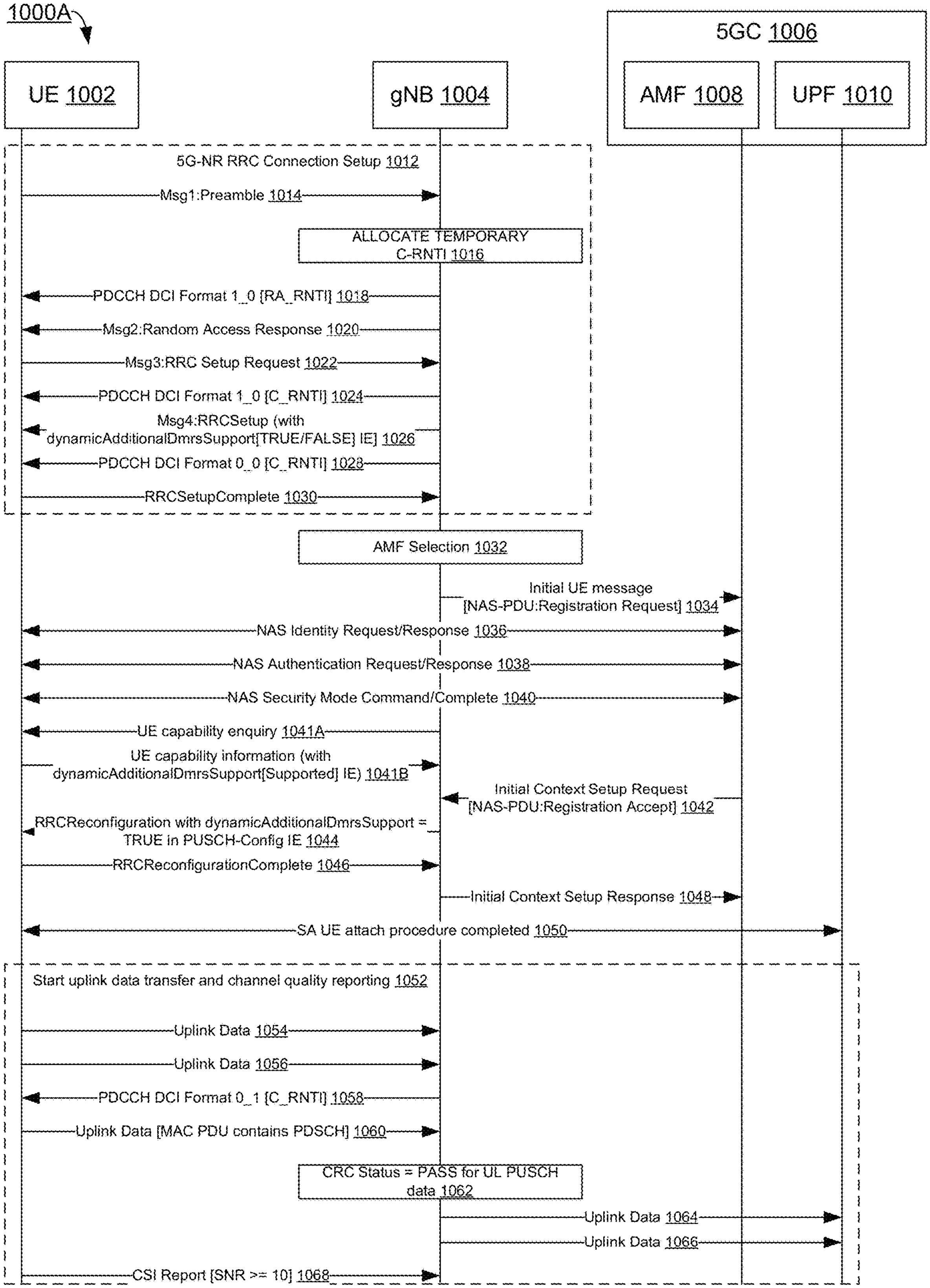

1000A
5GC 1006
UE 1002
gNB 1004
AMF 1008
UPF 1010
5G-NR RRC Connection Setup 1012
Msg1:Preamble 1014
ALLOCATE TEMPORARY C-RNTI 1016
PDCCH DCI Format 1_0 [RA_RNTI] 1018
Msg2:Random Access Response 1020
Msg3:RRC Setup Request 1022
PDCCH DCI Format 1_0 [C_RNTI] 1024
Msg4:RRCSetup (with dynamicAdditionalDmrsSupport[TRUE/FALSE] IE] 1026
PDCCH DCI Format 0_0 [C_RNTI] 1028
RRCSetupComplete 1030
AMF Selection 1032
Initial UE message [NAS-PDU:Registration Request] 1034
NAS Identity Request/Response 1036
NAS Authentication Request/Response 1038
NAS Security Mode Command/Complete 1040
UE capability enquiry 1041A
UE capability information (with dynamicAdditionalDmrsSupport[Supported] IE) 1041B
Initial Context Setup Request [NAS-PDU:Registration Accept] 1042
RRCReconfiguration with dynamicAdditionalDmrsSupport = TRUE in PUSCH-Config IE 1044
RRCReconfigurationComplete 1046
Initial Context Setup Response 1048
SA UE attach procedure completed 1050
Start uplink data transfer and channel quality reporting 1052
Uplink Data 1054
Uplink Data 1056
PDCCH DCI Format 0_1 [C_RNTI] 1058
Uplink Data [MAC PDU contains PDSCH] 1060
CRC Status = PASS for UL PUSCH data 1062
Uplink Data 1064
Uplink Data 1066
CSI Report [SNR >= 10] 1068

FIG. 10A

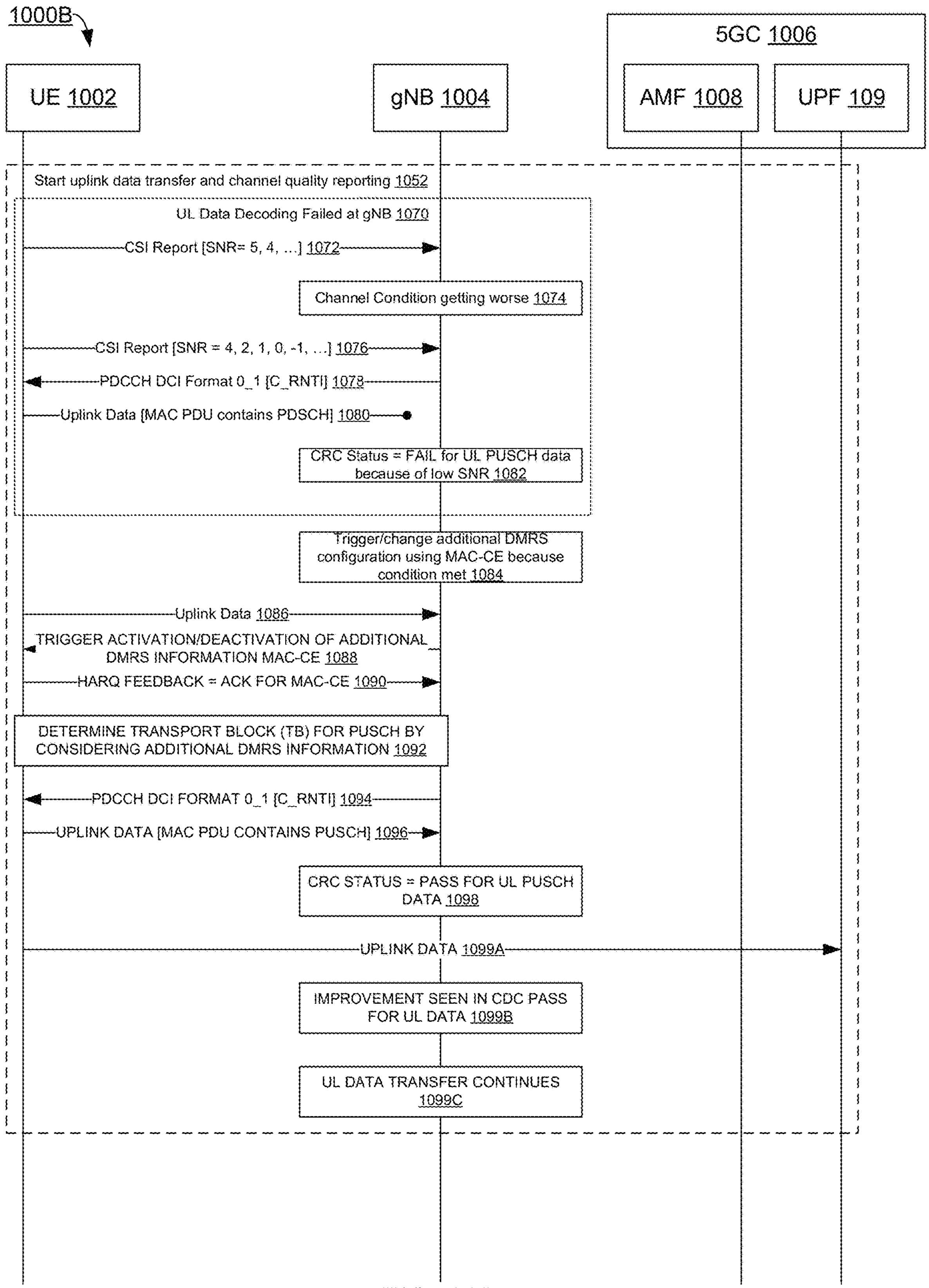

1000B
5GC 1006
UE 1002
gNB 1004
AMF 1008
UPF 109
Start uplink data transfer and channel quality reporting 1052
UL Data Decoding Failed at gNB 1070
CSI Report [SNR= 5, 4, ...] 1072
Channel Condition getting worse 1074
CSI Report [SNR = 4, 2, 1, 0, -1, ...] 1076
PDCCH DCI Format 0_1 [C_RNTI] 1078
Uplink Data [MAC PDU contains PDSCH] 1080
CRC Status = FAIL for UL PUSCH data because of low SNR 1082
Trigger/change additional DMRS configuration using MAC-CE because condition met 1084
Uplink Data 1086
TRIGGER ACTIVATION/DEACTIVATION OF ADDITIONAL DMRS INFORMATION MAC-CE 1088
HARQ FEEDBACK = ACK FOR MAC-CE 1090
DETERMINE TRANSPORT BLOCK (TB) FOR PUSCH BY CONSIDERING ADDITIONAL DMRS INFORMATION 1092
PDCCH DCI FORMAT 0_1 [C_RNTI] 1094
UPLINK DATA [MAC PDU CONTAINS PUSCH] 1096
CRC STATUS = PASS FOR UL PUSCH DATA 1098
UPLINK DATA 1099A
IMPROVEMENT SEEN IN CDC PASS FOR UL DATA 1099B
UL DATA TRANSFER CONTINUES 1099C

FIG. 10B

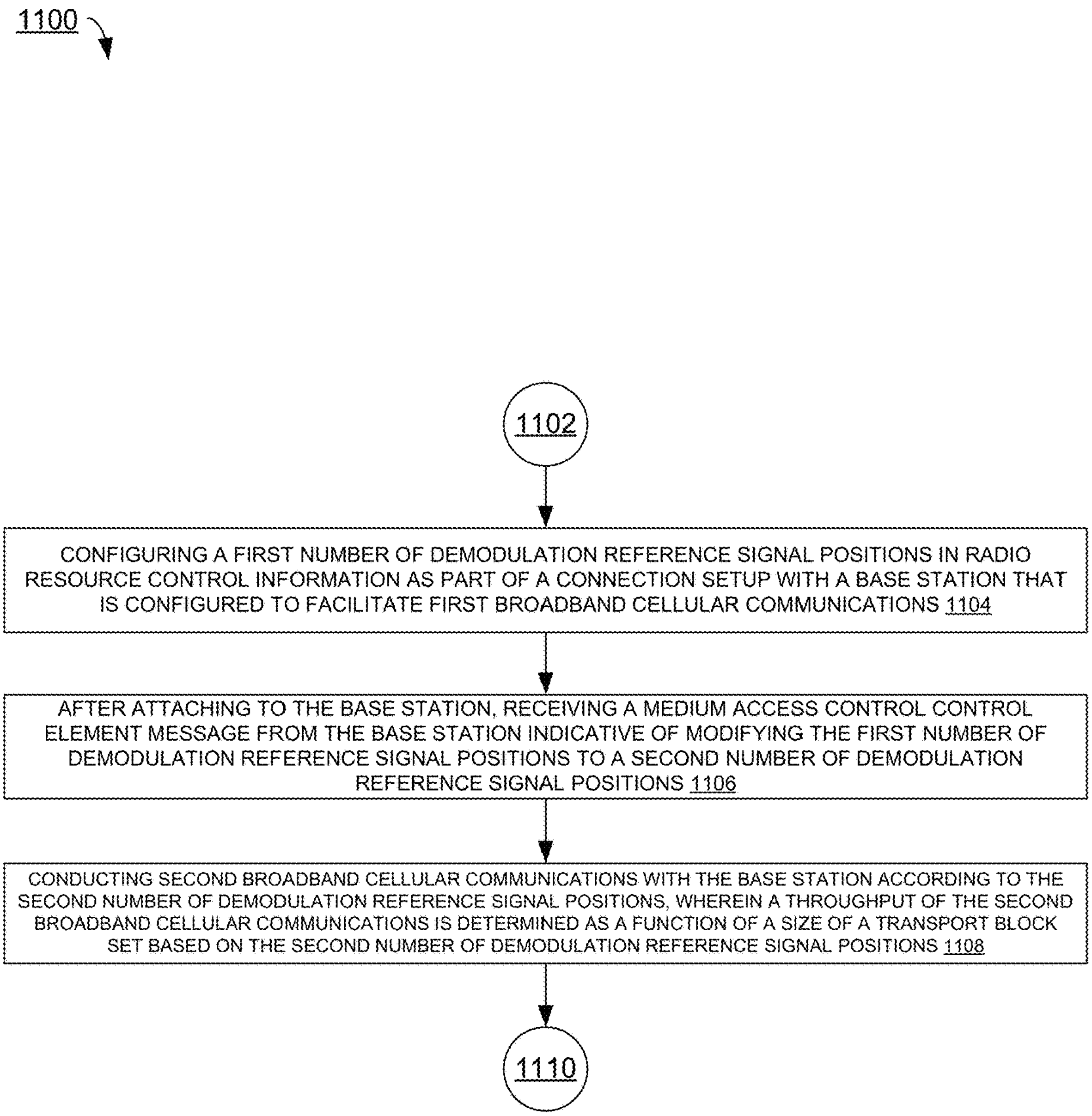

1100
1102
CONFIGURING A FIRST NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS IN RADIO RESOURCE CONTROL INFORMATION AS PART OF A CONNECTION SETUP WITH A BASE STATION THAT IS CONFIGURED TO FACILITATE FIRST BROADBAND CELLULAR COMMUNICATIONS 1104
AFTER ATTACHING TO THE BASE STATION, RECEIVING A MEDIUM ACCESS CONTROL CONTROL ELEMENT MESSAGE FROM THE BASE STATION INDICATIVE OF MODIFYING THE FIRST NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS TO A SECOND NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS 1106
CONDUCTING SECOND BROADBAND CELLULAR COMMUNICATIONS WITH THE BASE STATION ACCORDING TO THE SECOND NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS, WHEREIN A THROUGHPUT OF THE SECOND BROADBAND CELLULAR COMMUNICATIONS IS DETERMINED AS A FUNCTION OF A SIZE OF A TRANSPORT BLOCK SET BASED ON THE SECOND NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS 1108
1110

FIG. 11

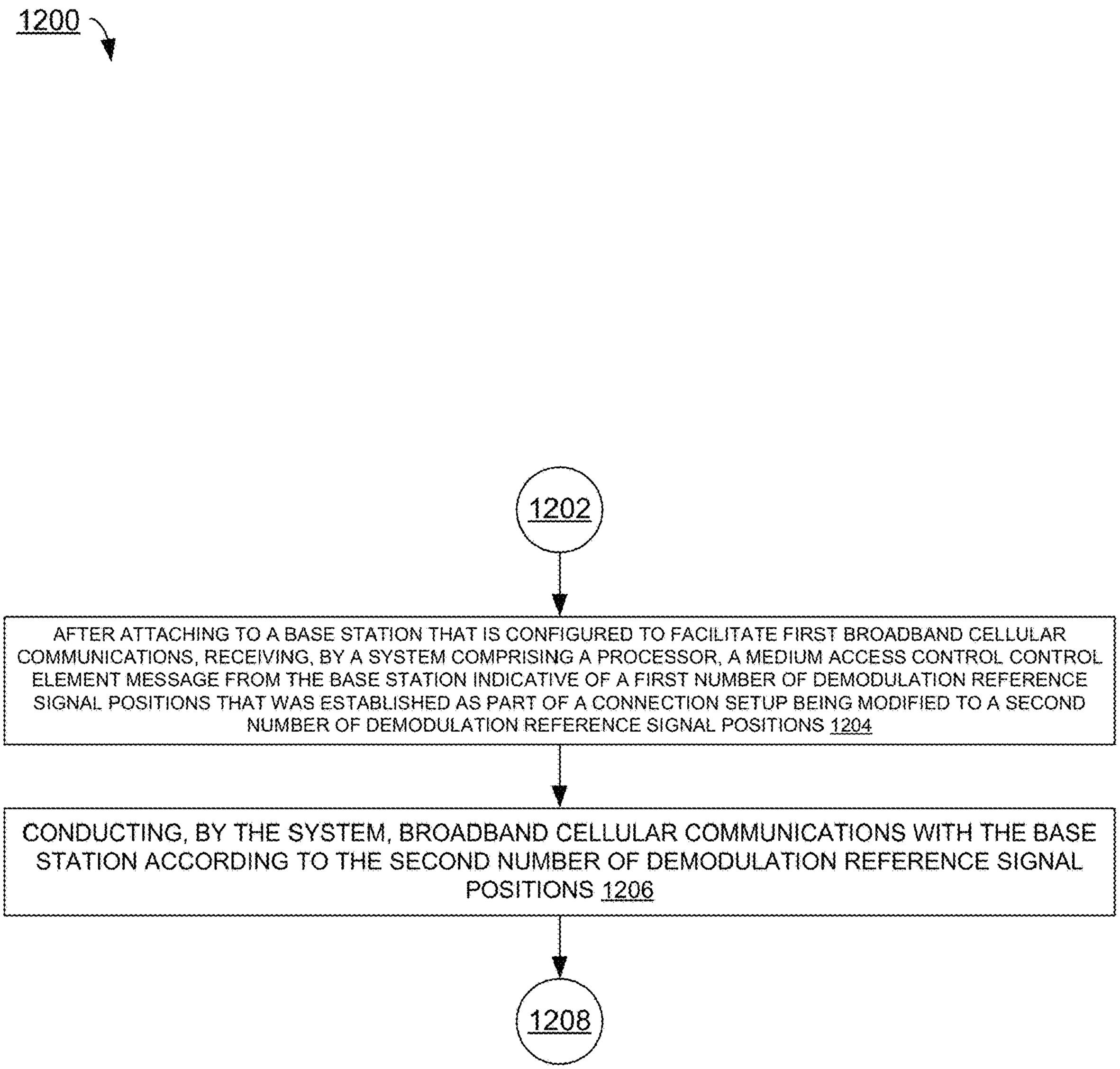

1200
1202
AFTER ATTACHING TO A BASE STATION THAT IS CONFIGURED TO FACILITATE FIRST BROADBAND CELLULAR COMMUNICATIONS, RECEIVING, BY A SYSTEM COMPRISING A PROCESSOR, A MEDIUM ACCESS CONTROL CONTROL ELEMENT MESSAGE FROM THE BASE STATION INDICATIVE OF A FIRST NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS THAT WAS ESTABLISHED AS PART OF A CONNECTION SETUP BEING MODIFIED TO A SECOND NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS 1204
CONDUCTING, BY THE SYSTEM, BROADBAND CELLULAR COMMUNICATIONS WITH THE BASE STATION ACCORDING TO THE SECOND NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS 1206
1208

FIG. 12

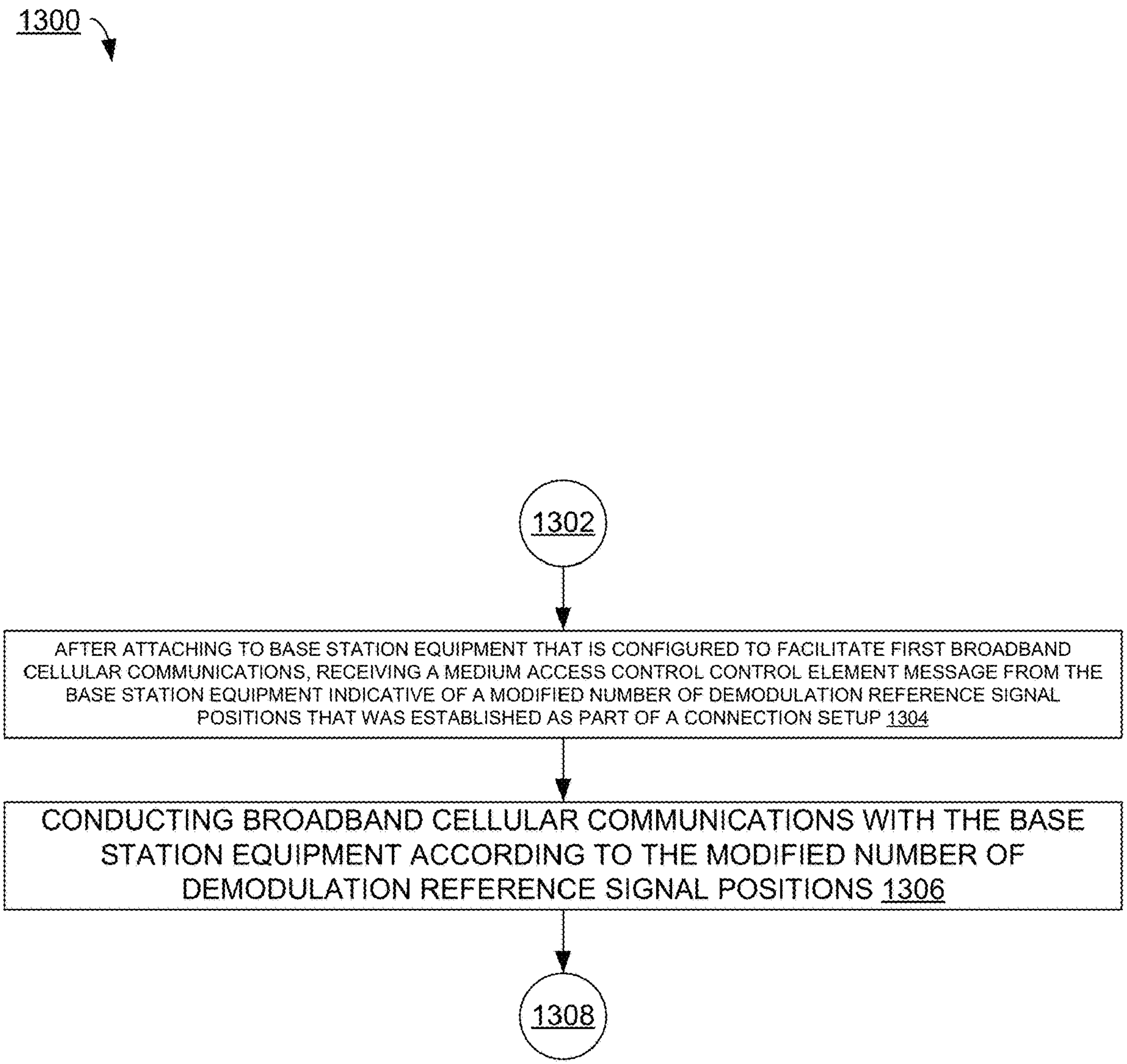

1300
1302
AFTER ATTACHING TO BASE STATION EQUIPMENT THAT IS CONFIGURED TO FACILITATE FIRST BROADBAND CELLULAR COMMUNICATIONS, RECEIVING A MEDIUM ACCESS CONTROL CONTROL ELEMENT MESSAGE FROM THE BASE STATION EQUIPMENT INDICATIVE OF A MODIFIED NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS THAT WAS ESTABLISHED AS PART OF A CONNECTION SETUP 1304
CONDUCTING BROADBAND CELLULAR COMMUNICATIONS WITH THE BASE STATION EQUIPMENT ACCORDING TO THE MODIFIED NUMBER OF DEMODULATION REFERENCE SIGNAL POSITIONS 1306
1308

FIG. 13

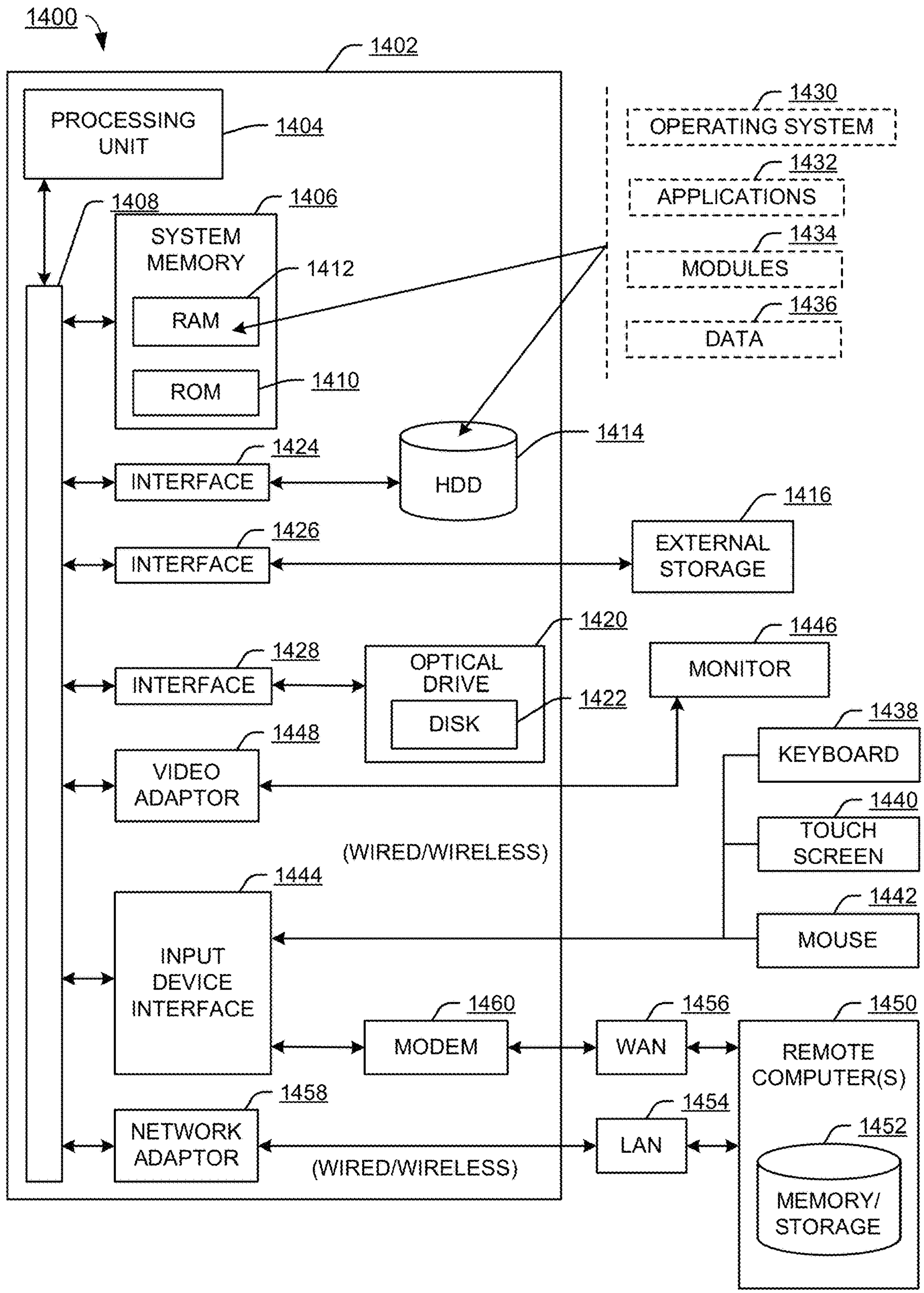

1400
1402
PROCESSING UNIT
1404
1408
SYSTEM MEMORY
1406
1412
RAM
ROM
1410
1430
OPERATING SYSTEM
1432
APPLICATIONS
1434
MODULES
1436
DATA
1414
HDD
1424
INTERFACE
1426
INTERFACE
1416
EXTERNAL STORAGE
1420
OPTICAL DRIVE
DISK
1422
1428
INTERFACE
1446
MONITOR
1448
VIDEO ADAPTOR
1438
KEYBOARD
1440
TOUCH SCREEN
(WIRED/WIRELESS)
1444
1442
MOUSE
INPUT DEVICE INTERFACE
1460
MODEM
1456
WAN
1450
REMOTE COMPUTER(S)
1458
NETWORK ADAPTOR
1454
LAN
(WIRED/WIRELESS)
1452
MEMORY/ STORAGE

FIG. 14

DYNAMIC ADDITIONAL DEMODULATION REFERENCE SIGNAL CONFIGURATION

BACKGROUND

In cellular broadband communications, a user equipment and a core network can communicate to configure a protocol to use in making further communications.

SUMMARY

The following presents a simplified summary of the disclosed subject matter in order to provide a basic understanding of some of the various embodiments. This summary is not an extensive overview of the various embodiments. It is intended neither to identify key or critical elements of the various embodiments nor to delineate the scope of the various embodiments. Its sole purpose is to present some concepts of the disclosure in a streamlined form as a prelude to the more detailed description that is presented later.

An example system can operate as follows. The system can configure a first number of demodulation reference signal positions in radio resource control information as part of a connection setup with a base station that is configured to facilitate first broadband cellular communications. The system can, after attaching to the base station, receive a medium access control control element message from the base station indicative of modifying the first number of demodulation reference signal positions to a second number of demodulation reference signal positions. The system can conduct second broadband cellular communications with the base station according to the second number of demodulation reference signal positions, wherein a throughput of the second broadband cellular communications is determined as a function of a size of a transport block set based on the second number of demodulation reference signal positions.

An example method can comprise, after attaching to a base station that is configured to facilitate first broadband cellular communications, receiving, by a system comprising a processor, a medium access control control element message from the base station indicative of a first number of demodulation reference signal positions that was established as part of a connection setup being modified to a second number of demodulation reference signal positions. The method can further comprise conducting, by the system, broadband cellular communications with the base station according to the second number of demodulation reference signal positions.

An example non-transitory computer-readable medium can comprise instructions that, in response to execution, cause a system comprising a processor to perform operations. These operations can comprise, after attaching to base station equipment that is configured to facilitate first broadband cellular communications, receiving a medium access control control element message from the base station equipment indicative of a modified number of demodulation reference signal positions that was established as part of a connection setup. These operations can further comprise conducting broadband cellular communications with the base station equipment according to the modified number of demodulation reference signal positions.

BRIEF DESCRIPTION OF THE DRAWINGS

Numerous embodiments, objects, and advantages of the present embodiments will be apparent upon consideration of

the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

FIG. **1** illustrates an example demodulation reference signal (DMRS) downlink configuration information element that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIG. **2** illustrates an example DMRS uplink configuration information element that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIGS. **3**A and **3**B illustrate an example additional DMRS configuration that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIGS. **4**A and **4**B illustrate another example additional DMRS configuration that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIGS. **5**A and **5**B illustrate another example additional DMRS configuration that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIGS. **6**A and **6**B illustrate another example additional DMRS configuration that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIG. **7** illustrates an example system architecture that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIG. **8** illustrates an example Medium Access Control Control Element message format for activation/deactivation of additional DRMS information, and that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure.

FIGS. **9**A and **9**B illustrate an example signal flow for dynamic additional DMRS configuration for a downlink, and that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIGS. **10**A and **10**B illustrates an example signal flow for dynamic additional DMRS configuration for a uplink, and that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure;

FIG. **11** illustrates an example process flow that can facilitate dynamic additional DMRS configuration, in accordance with an embodiment of this disclosure;

FIG. **12** illustrates another example process flow that can facilitate dynamic additional DMRS configuration, in accordance with an embodiment of this disclosure;

FIG. **13** illustrates another example process flow that can facilitate dynamic additional DMRS configuration, in accordance with an embodiment of this disclosure;

FIG. **14** illustrates an example block diagram of a computer operable to execute an embodiment of this disclosure.

DETAILED DESCRIPTION

The examples described herein can generally relate to actions taken by user equipment in communicating with a base station to dynamically configure additional demodulation reference signals. This dynamic configuration of additional demodulation reference signals can be established via a Medium Access Control Control Element (MAC-CE) message. In some examples, a MAC-CE message is sent at a MAC layer of cellular communications. Communications conducted at a MAC layer can be faster as compared to, for example, Radio Resource Control (RRC) layer communications.

In some examples of cellular communications, RRC and Non-access stratum (NAS) layer messages can be used to exchange signaling between a base station and user equipment. A MAC layer communication path can be another such path. In MAC layer communications, unique MAC structures can be defined that carry certain control information. In some examples, a unique MAC structure can be implemented to carry control information, and this structure can be referred to as a MAC-CE.

A MAC-CE can work between a base station (MAC) and a user equipment (MAC) for fast signaling communication exchange without involving higher communication layers.

It can be appreciated that corresponding actions can be taken by a base station to also dynamically configure additional demodulation reference signals.

The examples herein generally relate to 5G cellular communications networks. It can be appreciated that the present techniques can be applied to other types of cellular communications networks for dynamically configuring additional demodulation reference signals (DMRSes).

A DMRS can be utilized by a 5G new radio (NR) receiver to produce channel estimates for demodulation of an associated physical channel. A design and mapping of each DMRS can be specific to each 5G physical channel (e.g., physical broadcast channel (PBCH), physical downlink control channel (PDCCH), physical downlink shared channel (PDSCH), physical uplink control channel (PUSCH), and physical uplink shared channel (PUCCH)). DMRS can be user equipment (UE) specific, and be transmitted on demand. In some examples, a DMRS does not extend outside of a scheduled physical resource of a channel it supports. DMRS can support massive multi-user multiple-input and multiple-output (MIMO). DMRS can be beamformed and, in some examples, support up to 12 orthogonal layers. A DMRS sequence for a cyclic-prefix orthogonal frequency division multiplexing (CP-OFDM) version can be quadrature phase shift keying (QPSK) based on Gold Sequences.

With respect to PDSCH, DMRS can comprise front-loaded DMRS symbols (e.g., either 1 or 2) that are located as follows:

1. Slot based (DMRS mapping type-A): This can be a fixed orthogonal frequency division multiplexing (OFDM) symbol regardless of PDSCH assignment and that is configurable between lo={2,3}.
2. Non-slot based (DMRS mapping type-B): This can be a first OFDM symbol assigned for PDSCH—e.g., mini slots.

In some examples, additional DMRS symbols can be configured in scenarios such as high-speed mobility (e.g., handover); when downlink (DL)/uplink (UL) block error ratio (BLER) is high, and UE-reported channel condition is poor; and when a UE is located on a cell edge, and, because of that, the UE is not able to decode or send DL and UL packets.

With regard to PUSCH DMRS, in an uplink, it can be that two waveform types are supported (e.g., CP-OFDM, and discrete Fourier transform-spread orthogonal frequency division multiplexing (DFT-S-OFDM)). A gold sequence can be used in CP-OFDM, and a Zadoff-Chu sequence can be used in DFT-S-OFDM. Front loaded DMRS symbols (e.g., either 1 or 2) can be located at a first OFDM symbol that is assigned for PUSCH.

The present techniques can be implemented to solve the following problems.

One problem that can be solved by implementing the present techniques can be when a 5G base station (sometimes referred to as gNodeB or gNB; or more generally a base station) includes an dmrs-AdditionalPosition information element (IE) using DMRS-DownlinkConfig and DMRS-UplinkConfig for downlink and uplink, respectively, during UE attach or another UE-specific procedure, then that configuration can stay with the UE during the lifetime of the scenario unless it is modified by a radio resource control (RRC) modification procedure.

A dmrs-AdditionalPosition IE for DL and UL is indicated in FIGS. **1** and **2**, respectively. That is, FIG. **1** illustrates an example DMRS downlink configuration information element **100** that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure. In example DMRS downlink configuration information element **100**, there is dmrs-AdditionalPosition **102**.

And FIG. **2** illustrates an example DMRS uplink configuration information element **200** that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure. In In example DMRS uplink configuration information element **200**, there is dmrs-AdditionalPosition **202**.

Once this configuration is received by the UE, then the gNB and the UE can consider that configuration while determining a transport block (TB; which can generally determine data throughput of the UE). A TB can vary based on a number of additional DMRS positions that are configured.

Data throughput (TP) can be inversely proportional to a number of configured additional DMRS positions—that is, where more additional DMRS symbols are configured then there can be less data throughput.

FIGS. **3**A and **3**B illustrate an example additional DMRS configuration **300**A and **300**B that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure. Example additional DMRS configuration **300**A and **300**B (as well as example additional DMRS configuration **400**A and **400**B of FIGS. **4**A and **4**B; example additional DMRS configuration **500**A and **500**B of FIGS. **5**A and **5**B; and example additional DMRS configuration **600**A and **600**B of FIGS. **6**A and **6**B) can have the following settings:

pdsch.NumLayers=4;
pdsch.MappingType='A';
pdsch.SymbolAllocation=[0 13]; % [startSymbol Length]
dmrs.DMRSconfigurationType=1;
dmrs.DMRSLength=1;
dmrs.DMRSTypeAPosition=2;
dmrs.NumCDMGroupsWithoutData=2;
dmrs.NIDNSCID=10;
dmrs.NSCID=0;

Additionally, example additional DMRS configuration **300**A and **300**B has "dmrs.DMRSAdditionalPosition=0;" which indicates that there are no additional DMRS positions configured. This configuration is illustrated in additional DMRS configuration **300**A and **300**B, which comprises port **1000 302**A (with subcarriers **304**A and OFDM symbols **306**A); port **1001 302**B (with subcarriers **304**B and OFDM symbols **306**B); port **1002 302**C (with subcarriers **304**C and OFDM symbols **306**C); and port **1003 302**D (with subcarriers **304**D and OFDM symbols **306**D).

Example additional DMRS configuration **300**A and **300**B also comprises dynamic additional DMRS configuration component **310** (which can comprise a computer component that implements the present techniques) and key **308**. As depicted, FIGS. **3**A and **3**B relate to a 4-port antenna configuration, and dynamic additional DMRS configuration component **310** can comprise a 4-port dynamic additional DMRS configuration component.

FIGS. **4**A and **4**B illustrate another example additional DMRS configuration **400**A and **400**B that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure.

Example additional DMRS configuration **400**A and **400**B has “dmrs.DMRSAdditionalPosition=1;” which indicates that there is one additional DMRS position configured. This configuration is illustrated in additional DMRS configuration **400**A and **400**B, which comprises port **1000** **402**A (with subcarriers **404**A and OFDM symbols **406**A); port **1001** **402**B (with subcarriers **404**B and OFDM symbols **406**B); port **1002** **402**C (with subcarriers **404**C and OFDM symbols **406**C); and port **1003** **402**D (with subcarriers **404**D and OFDM symbols **406**D).

Example additional DMRS configuration **400**A and **400**B also comprises dynamic additional DMRS configuration component **410** (which can comprise a computer component that implements the present techniques) and key **408**.

FIGS. **5**A and **5**B illustrate another example additional DMRS configuration **500**A and **500**B that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure.

Example additional DMRS configuration **500**A and **500**B has “dmrs.DMRSAdditionalPosition=2;” which indicates that there are two additional DMRS positions configured. This configuration is illustrated in additional DMRS configuration **500**A and **500**B, which comprises port **1000** **502**A (with subcarriers **504**A and OFDM symbols **506**A); port **1001** **502**B (with subcarriers **504**B and OFDM symbols **506**B); port **1002** **502**C (with subcarriers **504**C and OFDM symbols **506**C); and port **1003** **502**D (with subcarriers **504**D and OFDM symbols **506**D).

Example additional DMRS configuration **500**A and **500**B also comprises dynamic additional DMRS configuration component **510** (which can comprise a computer component that implements the present techniques) and key **508**.

FIGS. **6**A and **6**B illustrate another example additional DMRS configuration **600**A and **600**B that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure.

Example additional DMRS configuration **600**A and **600**B has “dmrs.DMRSAdditionalPosition=3;” which indicates that there are three additional DMRS positions configured. This configuration is illustrated in additional DMRS configuration **600**A and **600**B, which comprises port **1000** **602**A (with subcarriers **604**A and OFDM symbols **606**A); port **1001** **602**B (with subcarriers **604**B and OFDM symbols **606**B); port **1002** **602**C (with subcarriers **604**C and OFDM symbols **606**C); and port **1003** **602**D (with subcarriers **604**D and OFDM symbols **606**D).

Example additional DMRS configuration **600**A and **600**B also comprises dynamic additional DMRS configuration component **610** (which can comprise a computer component that implements the present techniques) and key **608**.

In the example of FIGS. **3**A and **3**B, there is no additional DMRS configured. In the example of FIGS. **4**A and **4**B, there is one additional DMRS symbol configured. In the example of FIGS. **5**A and **5**B, there are two additional DMRS symbols configured. In the example of FIGS. **6**A and **6**B, there are three additional DMRS symbols configured. So, in these examples, data throughput in FIGS. **3**A and **3**B can be greater than in FIGS. **4**A and **4**B, which can be greater than in FIGS. **5**A and **5**B, which can be greater than in FIGS. **6**A and **6**B.

As part of dynamically configuring additional DMRS positions, a component (e.g., dynamic additional DMRS configuration component **310** of FIGS. **3**A and **3**B) can dynamically switch between the configurations of FIGS. **4**A and **4**B, **5**A and **5**B, and **6**A and **6**B

One problem with additional DMRS configuration can be physical resource block (PRB) wastage because of an unnecessarily-configured higher additional DMRS position. Implementing the present techniques to dynamically change the additional DMRS position can be implemented to solve this problem.

Take an example where, during UE attach, a gNB configured an additional DMRS configuration in pos3 (indicating 3 additional DMRS symbols). Where radio/channel condition is good, where the UE is reporting a channel quality indicator (CQI), and UL and DL data BLER % are under 1% (indicating that a PDSCH and PUSCH packet decoding success rate is high), then having 3 symbols for additional DMRS can negatively impact data throughput.

Some prior approaches do not allow changing this configuration dynamically, and because of that, the gNB can be unnecessarily wasting a physical resource block.

Another problem with additional DMRS configuration can relate to frequent UE release, or a UE performing a RRC reestablishment procedure because channel condition is poor. Implementing the present techniques to dynamically change the additional DMRS position can be implemented to solve this problem.

Take an example where, during UE attach, the gNB has not configured an additional DMRS configuration in DL and or UL. Where radio/channel condition is poor, where the UE is reporting CQI and UL and DL BLER % is high (e.g., >20%, which can indicate that a success rate of decoding PDSCH and PUSCH packets is poor), it can be that the UE or gNB can perform a UE release or RRC reestablishment procedure. This procedure can take a long time to restore the connection. This problem can be avoided by dynamically configuring additional DMRS positions to sustain the connection. In some prior approaches, this configuration cannot be dynamically altered.

Another problem with additional DMRS configuration can relate to a high-speed mobility (handover) scenario. In a high-speed handover scenario, channel/radio condition can be kept on very frequently, to sustain and maintain good quality for a call. Additional DMRS symbols can be adapted dynamically based on reported CQI and BLER, to achieve good throughput, while also not compromising by wasting physical resources.

Another problem with additional DMRS configuration can relate to a scenario where a UE is located at a cell edge. It can be that, when a UE is located at a cell edge, the UE's channel quality is subpar, BLER % can be high. To improve this condition, a gNB can quickly adapt an additional DMRS configuration. It can be that adapting a DMRS configuration based on link adaptation is not supported by prior approaches.

The present techniques for dynamic additional DMRS configuration can be implemented as follows.

In some examples, an IE in UE capability for downlink and uplink can be implemented to support dynamic additional DMRS configuration. An IE (“dynamicAdditionalDMRSSupport”) for downlink can be implemented in FeatureSetDownlink. Where a UE supports this IE, it can mean that the UE supports dynamic additional DMRS configuration change in the downlink direction.

An IE ("dynamicAdditionalDMRSSupport") for uplink can be implemented in FeatureSetUplink. Where a UE supports this IE, it can mean that the UE supports dynamic additional DMRS configuration change in the uplink direction.

In some examples, an IE ("dynamicAdditionalDmrsSupport") can be implemented in PDSCH-Config for downlink, and in PUSCH-Config for uplink.

FIG. **7** illustrates an example system architecture **700** that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure. System architecture comprises gNB **702**, UE **704**, CQI processing **706**, inner loop link adaptation (ILLA) **708**, and gNB outer loop link adaptation (OLLA) **710** (which, in some examples, can more generally be a base station outer loop link adaptation).

In some examples, gNB **702** can determine additional DMRS information dynamically, as follows. As depicted in FIG. **7**, where UE **704** is reporting channel quality using CQI, and hybrid automatic repeat request (HARQ) feedback (e.g., acknowledgment (ACK), negative acknowledgment (NACK), and discontinuous transmission (DTX)) for data transmission then, OLLA **710** can handle the HARQ feedback, and CQI processing **706** can handle CQI reported by UE **704**.

Based on these two inputs, ILLA **708** can determine a modulation coding scheme (MCS) and additional DMRS position to be applied to UL and DL data transmission.

ILLA **708** can determine the MCS by considering the CQI reported by UE **704**, and HARQ feedback. In some examples, the higher the MCS, the better the channel/radio quality, meaning a smaller number of additional DMRS positions configured to UE **704** using the present techniques.

Where ILLA **708** determines to use a lower MCS, meaning the channel quality reported by UE **704** is not good and BLER is high, this can mean that ILLA **708** determines to increase the additional DMRS position in DL/UL DCI to decrease the BLER %.

The following can be communicated as part of conveying capability of a UE. A FeatureSetCombination information element can be as follows:

```
-- ASN1START
-- TAG-FEATURESETCOMBINATION-START
FeatureSetCombination ::=          SEQUENCE (SIZE
(1..maxSimultaneousBands) ) OF FeatureSetsPerBand
FeatureSetsPerBand ::=             SEQUENCE (SIZE
(1..maxFeatureSetsPerBand) ) OF FeatureSet
FeatureSet ::=                     CHOICE {
  eutra                              SEQUENCE {
    downlinkSetEUTRA                   FeatureSet EUTRA-
DownlinkId,
    uplinkSetEUTRA                     FeatureSetEUTRA-
UplinkId
  },
  nr                                 SEQUENCE {
    downlinkSetNR
FeatureSetDownlinkId,
    uplinkSetNR                        FeatureSetUplinkId
  }
}
-- TAG-FEATURESETCOMBINATION-STOP
-- ASN1STOP
```

An IE, FeatureSetDownlink, can indicate a set of features that a UE supports on carriers corresponding to one band entry in a band combination. A FeatureSetDownlink IE can be as follows:

```
-- ASN1START
-- TAG-FEATURESETDOWNLINK-START
FeatureSetDownlink ::=                       SEQUENCE {
  featureSetListPerDownlinkCC                  SEQUENCE (SIZE
(1..maxNrofServingCells) ) OF FeatureSetDownlinkPerCC-Id,
  intraBandFreqSeparationDL
FreqSeparationClass
OPTIONAL,
  scalingFactor                                ENUMERATED
{f0p4, f0p75, f0p8}
OPTIONAL,
  crossCarrierScheduling-OtherSCS              ENUMERATED
{supported}
OPTIONAL,
  scellWithoutSSB                              ENUMERATED
{supported}
OPTIONAL,
  csi-RS-MeasSCellWithoutSSB                   ENUMERATED
{supported}
OPTIONAL,
  ...................
    -- An IE to indicate UE capability to support downlink
dynamic additional DMRS feature.
  dynamicAdditionalDMRSSupport                 ENUMERATED
{supported}
OPTIONAL,
  ...................
  dummy1                                       ENUMERATED
{supported}
OPTIONAL,
  dummy6                                       SEQUENCE (SIZE
(1..maxNrofCodebooks) ) OF DummyD
OPTIONAL,
  dummy7                                       SEQUENCE (SIZE
(1..maxNrofCodebooks) ) OF DummyE
OPTIONAL
}
-- TAG-FEATURESETDOWNLINK-STOP
-- ASN1STOP
```

In a FeatureSetDownlink IE, a UE can set a dynamicAdditionalDMRSSupport field to support where the UE is capable of supporting downlink additional DMRS features.

An IE, FeatureSetUplink, can indicate a set of features that a UE supports on carriers corresponding to one band entry in a band combination. A FeatureSetUplink IE can be as follows:

```
-- ASN1START
-- TAG-FEATURESETUPLINK-START
FeatureSetUplink ::=                   SEQUENCE {
    featureSetListPerUplinkCC            SEQUENCE (SIZE (1..
maxNrofServingCells) ) OF FeatureSetUplinkPerCC-Id,
    scalingFactor                        ENUMERATED {f0p4,
f0p75, f0p8}
OPTIONAL,
    crossCarrierScheduling-OtherSCS      ENUMERATED
{supported}
OPTIONAL,
    intraBandFreqSeparationUL            FreqSeparationClass
OPTIONAL,
    searchSpaceSharingCA-UL              ENUMERATED
{supported}
OPTIONAL,
  .....................
        -- An IE to indicate UE capability to support Uplink
dynamic additional DMRS feature.
    dynamicAdditionalDMRSSupport         ENUMERATED
{supported}
OPTIONAL,
    ....................
    dummy1                               DummyI
OPTIONAL,
    supportedSRS-Resources               SRS-Resources
OPTIONAL,
    twoPUCCH-Group                       ENUMERATED
{supported}
```

-continued

```
OPTIONAL,
     dynamicSwitchSUL                    ENUMERATED
{supported}
OPTIONAL,
     simultaneousTxSUL-NonSUL            ENUMERATED
{supported}
OPTIONAL,
     pusch-ProcessingType1-DifferentTB-PerSlot SEQUENCE {
        scs-15kHz                            ENUMERATED
{upto2, upto4, upto7}
OPTIONAL,
        scs-30kHz                            ENUMERATED
{upto2, upto4, upto7}
OPTIONAL,
        scs-60kHz                            ENUMERATED
{upto2, upto4, upto7}
OPTIONAL,
        scs-120kHz                           ENUMERATED
{upto2, upto4, upto7}
OPTIONAL
     }
OPTIONAL,
     dummy2                              DummyF
OPTIONAL
}
-- TAG-FEATURESETUPLINK-STOP
-- ASN1STOP
```

In a FeatureSetUplink IE, a UE can set a dynamicAdditionalDMRSSupport field to support where the UE is capable of supporting uplink additional DMRS features.

FIG. **8** illustrates an example MAC-CE message format **800** for activation/deactivation of additional DRMS information, and that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure.

A MAC CE message can be sent between a base station (MAC) and user equipment (MAC) for fast signaling communication exchange, without involving upper layers.

A 3rd Generation Partnership Project (3GPP) protocol can give a provision to send control information using a MAC-CE message (or DCI). Activation and/or deactivation of DMRS using MAC-CE can be a one-time procedure. That is, it can take one-time physical resources for sending this CE.

Example MAC-CE message format **800** comprises MAC-CE message and Additional DMRS Position **820**. In turn, MAC-CE message **810** can comprise bit **812**, octet 1 **814**, and octet 2 **816**. Additional DMRS position indication **820** comprises index **822** and additional DMRS position **824**.

In MAC-CE message **810**, bit **812** indicates a bit number for octet 1 **814** and octet 2 **816**. There are 8 bits, numbered 0-7. Octet 1 **814** can store the following information: bit 7 can be reserved (R); bit 6 can store an identifier for direction (D being downlink, and U being uplink); bits 5-1 can store a logical channel identifier (LCID).

Octet 2 **816** can store the following information: bits 7-2 can be reserved (R); and bits 1-0 can store additional DMRS position indication **820**.

In additional DMRS position indication **820**, index **822** indicates a value stored in bits 1-0 of octet 2 **816**, and additional DMRS position **824** indicates a corresponding number of additional DMRS positions.

There are four possible index values in index **822**, and those four values can be expressed in binary in the two bits of bits 1-0 of octet 2 **816**.

FIG. **9** illustrates an example signal flow **900** for dynamic additional DMRS configuration for a downlink, and that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure. As depicted, in signal flow **900**, communications are sent between user equipment **902**, gNB **904**, and 5G core (5GC) **906** (which comprises access and mobility management function (AMF) **908** and user plane function (UPF) **910**).

The signal flow of signal flow **900** is an example signal flow, and there can be signal flows that implement different signals, or the signals of signal flow **900** in a different order, as part of facilitating dynamic additional DMRS configuration.

As depicted in signal flow **900**, the following occurs:

5G-NR RRC connection setup **912**

Msg1:Preamble **914**

Allocate temporary Cell Radio Network Temporary Identifier (C-RNTI) **916**

PDCCH DCI Format 1_0 [Random Access RNTI (RA_RNTI)] **918**

Msg2:Random Access Response **920**

Msg3:RRCSetupRequest **922**

PDCCH DCI Format 1_0 [C_RNTI] **924**

Msg4:RRCSetup **926**, where a dynamicAdditionalDmrsSupport[TRUE/FALSE] IE is contained in this message, and can be added as part of the present techniques

PDCCH DCI Format 0_0 [C_RNTI] **928**

RRCSetupComplete **930**

AMF Selection **932**

Initial UE message [Non-Access-Stratum-Protocol Data Unit (NAS-PDU):Registration Request] **934**

NAS Identity Request/Response **936**

NAS Authentication Request/Response **938**

NAS Security Mode Command/Complete **940**

UE capability enquiry **941**A

UE capability information, with dynamicAdditionalDmrsSupport[Supported] IE in FeatureSetDownlink **941**B

Initial Context Setup Request [NAS-PDU:Registration Accept] **942**

RRCReconfiguration with dynamicAdditionalDmrsSupport=TRUE in PDSCH-Config IE where UE supports this feature in downlink **944** (which can indicate that the UE already supports a dynamic additional DMRS feature that is communicated by the UE in **941**B as part of UE capability information; here, a gNB can add this IE in a RRCE Reconfiguration message)

RRCReconfigurationComplete **946**

Initial Context Setup Response **948**

Standalone (SA) UE attach procedure completed **950**

Start downlink data transfer and channel quality reporting **952**

Downlink data **954**

Downlink data **956**

PDCCH DCI Format 1_1 [C_RNTI] **958**

Downlink Data [Medium Access Control (MAC) PDU contains PDSCH] **960**

HARQ Feedback=ACK **962**

Channel State Information (CSI) Report [CQI=15] **964**

DL data decoding failed at UE **966**

CSI Report [CQI=9, 7, 6, . . .] **968**

Channel condition gets worse **970**

CSI Report [CQI=4, 5, 1, . . .] **572**

PDCCH DCI Format 1_1 [C_RNTI] **974**

Downlink Data [MAC PDU contains PDSCH] **976**

HARQ Feedback=NACK **978**

HARQ Feedback=DTX **980**

Trigger/change additional DMRS configuration using MAC-CE because condition met **982**, where, in some examples, a condition can be CQI reporting is bad for a certain threshold and period; HARQ feedback is reported as NACK (e.g., BLER is high for a certain threshold and period); UE is on a cell edge; and/or UE is on high mobility

Downlink Data **984**

Trigger activation/deactivation of additional DMRS information MAC-CE **986**

HARQ Feedback=ACK for MAC-CE **988**

Determine transport block (TB) for PDSCH by considering additional DMRS information **990**

PDCCH DCI Format 1_1 [C_RNTI] **992**

Downlink Data [MAC PDU contains PDSCH] **994**

HARQ Feedback=ACK **996**

Downlink data **998**

Improvement seen in UE throughput for DL Data **999**A

DL Data transfer continues **999**B

FIG. **10** illustrates an example signal flow for dynamic additional DMRS configuration for a uplink, and that can facilitate dynamic additional DMRS configuration in accordance with an embodiment of this disclosure.

As depicted, in signal flow **1000**, communications are sent between user equipment **1002**, gNB **1004**, and 5GC **1006** (which comprises AMF **1008** and UPF **1010**).

The signal flow of signal flow **1000** is an example signal flow, and there can be signal flows that implement different signals, or the signals of signal flow **1000** in a different order, as part of facilitating dynamic additional DMRS configuration.

As depicted in signal flow **1000**, the following occurs:

5G-NR RRC connection setup **1012**

Msg1:Preamble **1014**

Allocate temporary C-RNTI **1016**

PDCCH DCI Format 1_0 [RA_RNTI] **1018**

Msg2:Random Access Response **1020**

Msg3:RRCSetupRequest **1022**

PDCCH DCI Format 1_0 [C_RNTI] **1024**

Msg4:RRCSetup **1026**, where a dynamicAdditionalDmrsSupport[TRUE/FALSE] IE is contained in this message, and can be added as part of the present techniques

PDCCH DCI Format 0_0 [C_RNTI] **1028**

RRCSetupComplete **1030**

AMF Selection **1032**

Initial UE message [NAS-PDU:Registration Request] **1034**

NAS Identity Request/Response **1036**

NAS Authentication Request/Response **1038**

NAS Security Mode Command/Complete **1040**

UE capability enquiry **1041**A

UE capability information, with dynamicAdditionalDmrsSupport[Supported] IE in FeatureSetUplink **1041**B

Initial Context Setup Request [NAS-PDU:Registration Accept] **1042**

RRCReconfiguration with dynamicAdditionalDmrsSupport=TRUE in PUSCH-Config IE where UE supports this feature in uplink **1044**

RRCReconfigurationComplete **1046**

Initial Context Setup Response **1048**

SA UE attach procedure completed **1050**

Start uplink data transfer and channel quality reporting **1052**

Uplink data **1054**

Uplink data **1056**

PDCCH DCI Format 0_1 [C_RNTI] **1058**

Uplink Data [MAC PDU contains PDSCH] **1060**

CRC status=PASS for UL PUSCH data **1062**

Uplink data **1064**

Uplink data **1066**

CSI Report [SNR>=10] **1068**

UL data decoding failed at gNB **1070**

CSI Report [SNR=5, 4, . . .] **1072**

Channel condition getting worse **1074**

CSI Report [SNR=4, 2, 1, 0, −1, . . .] **1076**

PDCCH DCI Format 0_1 [C_RNTI] **1078**

Uplink Data [MAC PDU contains PUSCH] **1080**

CRC Status=FAIL for UL PUSCH because of low SNR **1082**

Trigger/change additional DMRS configuration using MAC-CE because of a condition **1084**, where, in some examples, a condition can be UL SNR reporting is bad for a certain threshold and period; UL CRC fails because SNR is low (e.g., BLER is high for a certain threshold and period); UE is on a cell edge; and/or UE is on high mobility

Uplink data **1086**

Trigger activation/deactivation of additional DMRS information MAC-CE **1088**

HARQ Feedback=ACK for MAC-CE **1090**

Determine transport block (TB) for PUSCH by considering additional DMRS information **1092**

PDCCH DCI Format 0_1 [C_RNTI] **1094**

Uplink Data [MAC PDU contains PUSCH] **1096**

CRC Status=PASS for UL PUSCH data **1098**

Uplink data **1099**A

Improvement seen in CDC PASS for UL Data **1099**B

UL Data transfer continues **1099**C

User equipment **1002**, gNB **1004**, 5GC **1006**, AMF **1008**, and UPF **1010** can be similar to user equipment **902**, gNB **904**, 5GC **906**, AMF **908**, and UPF **910** of FIGS. **9**A and **9**B, respectively. Signals **1012**-**1050** can be similar to signals **912**-**950**. Additionally, in signals **1012**-**1050**, an IE dynamicAdditionalDmrsSupport can be available for downlink, and an uplink structure can be different relative to signals **912**-**950** of FIG. **9**A.

Example Process Flows

FIG. **11** illustrates an example process flow **1100** that can facilitate dynamic additional DMRS configuration, in accordance with an embodiment of this disclosure. In some examples, one or more embodiments of process flow **1100** can be implemented by UE **902** of FIGS. **9**A and **9**B, UE **1002** of FIGS. **10**A and **10**B, and/or computing environment **1400** of FIG. **14**.

It can be appreciated that the operating procedures of process flow **1100** are example operating procedures, and that there can be embodiments that implement more or fewer operating procedures than are depicted, or that implement the depicted operating procedures in a different order than as depicted. In some examples, process flow **1100** can be implemented in conjunction with one or more embodiments of one or more of process flow **1200** of FIG. **12**, and/or process flow **1300** of FIG. **13**.

Process flow **1100** begins with **1102**, and moves to operation **1104**.

Operation **1104** depicts configuring a first number of demodulation reference signal positions in radio resource control information as part of a connection setup with a base station that is configured to facilitate first broadband cellular communications. This can comprise user equipment (e.g., UE **902** of FIGS. **9**A and **9**B) establishing a connection setup with a gNB (e.g., gNB **904** of FIGS. **9**A and **9**B), where the connection setup can be similar to connection setup **912** and/or connection setup **1012**. The first number of additional demodulation reference signal positions can be the number that are established as part of an attach procedure.

After operation **1104**, process flow **1100** moves to operation **1106**.

Operation **1106** depicts, after attaching to the base station, receiving a medium access control control element message from the base station indicative of modifying the first number of demodulation reference signal positions to a second number of demodulation reference signal positions. In some examples, this message can be similar to trigger activation/deactivation of additional DMRS information MAC-CE **986** of FIG. **9**B (in a case of downlink communications), and/or trigger activation/deactivation of additional DMRS information MAC-CE **1088** (in a case of uplink communications). The MAC-CE message can be similar in structure to that depicted with respect to FIG. **8**.

In some examples, operation **1106** comprises, in response to receiving the medium access control control element message, sending, to the base station, a hybrid automatic repeat request message that acknowledges the medium access control control element message. In some examples, this hybrid automatic repeat request message can be similar to HARQ Feedback=ACK for MAC-CE **988** of FIG. **9**B, and/or HARQ Feedback=ACK for MAC-CE **1090** of FIG. **10**B.

In some examples, the medium access control control element message indicates triggering activation of demodulation reference signal positions. In some examples, the medium access control control element message indicates triggering deactivation of demodulation reference signal positions. That is, a MAC-CE message can be used for both activating and deactivating additional DRMS positions.

In some examples, operation **1104** comprises, as part of the attaching to the base station, receiving, from the base station, a radio resource control setup message that indicates that the base station supports modification of the first number of demodulation reference signal positions after attaching to the base station. In some examples, this radio resource control setup message can be similar to Msg4: RRCSetup **926**, where a dynamicAdditionalDmrsSupport [TRUE/FALSE] IE is contained in this message, and can be added as part of the present techniques of FIG. **9**A, and/or Msg4:RRCSetup **1026**, where a dynamicAdditionalDmrsSupport[TRUE/FALSE] IE is contained in this message, and can be added as part of the present techniques of FIG. **10**A.

In some examples an information element of the radio resource control setup message indicates that the base station supports the modification of the first number of demodulation reference signal positions after attaching to the base station. That is, within the radio resource control message, a dynamicAdditionalDmrsSupport[TRUE/FALSE] IE can be contained, which indicates whether the base station supports dynamic modification of demodulation reference signal positions.

In some examples, operation **1106** comprises, before receiving the message from the base station indicative of modifying the first number of demodulation reference signal positions, receiving a radio resource control reconfiguration message that indicates that the base station supports modification of the first number of demodulation reference signal positions after attaching to the base station. This radio resource control reconfiguration message can be similar to RRCReconfiguration with dynamicAdditionalDmrsSupport=TRUE in PDSCH-Config IE where UE supports this feature in downlink **944**, and/or RRCReconfiguration with dynamicAdditionalDmrsSupport=TRUE in PUSCH-Config IE where UE supports this feature in uplink **1044**.

This radio resource control reconfiguration message can indicate that the UE already supports a dynamic additional DMRS feature that is communicated by the UE in **941**B or **1041**B as part of UE capability information. Here, a gNB can add this IE in a RRCE
Reconfiguration Message

In some examples, a physical downlink shared channel configuration information element of the radio resource control reconfiguration message indicates that the base station supports the modification of the first number of demodulation reference signal positions in downlink communications. That is, the IE can be similar to PDSCH-Config IE in RRCReconfiguration with dynamicAdditionalDmrsSupport=TRUE in PDSCH-Config IE where UE supports this feature in downlink **944**.

In some examples, a physical uplink shared channel configuration information element of the radio resource control reconfiguration message indicates that the base station supports the modification of the first number of demodulation reference signal positions in uplink communications. That is, the IE can be similar to PUSCH-Config IE in RRCReconfiguration with dynamicAdditionalDmrsSupport=TRUE in PUSCH-Config IE where UE supports this feature in uplink **1044**.

In some examples, operation **1106** comprises before receiving the message from the base station indicative of modifying the first number of demodulation reference signal positions, sending, to the base station, a user equipment capability message that indicates support for modification of the first number of demodulation reference signal positions after attaching to the base station. In some examples, this user equipment capability message can be similar to UE capability information, with dynamicAdditionalDmrsSupport[Supported] IE in FeatureSetDownlink **941**B of FIG. **9**A, and/or UE capability information, with dynamicAdditionalDmrsSupport[Supported] IE in FeatureSetUplink **1041**B of FIG. **10**A.

In some examples, an information element of the user equipment capability message indicates the support for the modification of the first number of demodulation reference signal positions after attaching to the base station. That is, within the user equipment capability message, a dynamicAdditionalDmrsSupport[Supported] IE can be contained, which indicates whether the user equipment supports dynamic modification of demodulation reference signal positions.

After operation **1106**, process flow **1100** moves to operation **1108**.

Operation **1108** depicts conducting second broadband cellular communications with the base station according to the second number of demodulation reference signal positions, wherein a throughput of the second broadband cellular communications is determined as a function of a size of a transport block set based on the second number of demodulation reference signal positions. This can comprise the user equipment using the dynamically configured additional DMRS positions, such as in DL data transfer continues **999**B of FIG. **9**B (in a case of downlink communications), and/or UL data transfer continues **1099**C of FIG. **10**B (in a case of uplink communications).

After operation **1108**, process flow **1100** moves to **1110**, where process flow **1100** ends.

FIG. **12** illustrates an example process flow **1200** that can facilitate dynamic additional DMRS configuration, in accordance with an embodiment of this disclosure. In some examples, one or more embodiments of process flow **1200** can be implemented by UE **902** of FIGS. **9**A and **9**B, UE **1002** of FIGS. **10**A and **10**B, and/or computing environment **1400** of FIG. **14**.

It can be appreciated that the operating procedures of process flow **1200** are example operating procedures, and that there can be embodiments that implement more or fewer operating procedures than are depicted, or that implement the depicted operating procedures in a different order than as depicted. In some examples, process flow **1200** can be implemented in conjunction with one or more embodiments of one or more of process flow **1100** of FIG. **11**, and/or process flow **1300** of FIG. **13**.

Process flow **1200** begins with **1202**, and moves to operation **1204**.

Operation **1204** depicts, after attaching to a base station that is configured to facilitate first broadband cellular communications, receiving, by a system comprising a processor, a medium access control control element message from the base station indicative of a first number of demodulation reference signal positions that was established as part of a connection setup being modified to a second number of demodulation reference signal positions. In some examples, operation **1204** can be implemented in a similar manner as operations **1104**-**1106** of FIG. **11**.

In some examples, the second number of demodulation reference signal positions is configured for uplink communications of the broadband cellular communications, and wherein the receiving the message from the base station is performed in response to sending uplink data to the base station. That is, the additional DMRS positions can be changed for uplink communications, and determining to change the additional DMRS positions can be made based on uplink data.

In some examples, the uplink data indicates that an uplink signal-to-noise ratio metric does not satisfy a threshold associated with a predetermined quality criterion for a defined amount of time, wherein a cyclic redundancy check that corresponds to the uplink data has failed or is failing, wherein the uplink data indicates that the system is connected to edge network equipment of a cellular network via which the broadband cellular communications are conducted, or wherein the uplink data indicates that the system satisfies a defined physical movement criterion.

After operation **1204**, process flow **1200** moves to operation **1206**.

Operation **1206** depicts conducting, by the system, broadband cellular communications with the base station according to the second number of demodulation reference signal positions. In some examples, operation **1306** can be implemented in a similar manner as operation **1108** of FIG. **11**.

After operation **1206**, process flow **1200** moves to **1208**, where process flow **1200** ends.

FIG. **13** illustrates an example process flow **1300** that can facilitate dynamic additional DMRS configuration, in accordance with an embodiment of this disclosure. In some examples, one or more embodiments of process flow **1300** can be implemented by UE **902** of FIGS. **9**A and **9**B, UE **1002** of FIGS. **10**A and **10**B, and/or computing environment **1400** of FIG. **14**.

It can be appreciated that the operating procedures of process flow **1300** are example operating procedures, and that there can be embodiments that implement more or fewer operating procedures than are depicted, or that implement the depicted operating procedures in a different order than as depicted. In some examples, process flow **1300** can be implemented in conjunction with one or more embodiments of one or more of process flow **1100** of FIG. **11**, and/or process flow **1200** of FIG. **12**.

Process flow **1300** begins with **1302**, and moves to operation **1304**. Operation **1304** depicts, after attaching to base station equipment that is configured to facilitate first broadband cellular communications, receiving a medium access control control element message from the base station equipment indicative of a modified number of demodulation reference signal positions that was established as part of a connection setup. In some examples, operation **1204** can be implemented in a similar manner as operations **1104**-**1106** of FIG. **11**.

In some examples, modifying the number of demodulation reference signal positions is performed for downlink communications of the broadband cellular communications, and wherein the receiving the message from the base station equipment is performed in response to sending hybrid automatic feedback that indicates failure or a channel quality indicator reporting metric to the base station equipment. That is, the additional DMRS positions can be changed for downlink communications, and determining to change the additional DMRS positions can be made based on downlink data.

In some examples, the channel quality indicator reporting metric does not satisfy a threshold associated with a defined threshold criterion for a defined amount of time. That is, CQI reporting can be bad for a defined threshold value and time period.

In some examples, the hybrid automatic feedback is being reported as a negative acknowledgement. That is, HARQ feedback can be reported as NACK.

In some examples, the hybrid automatic feedback is being reported as the negative acknowledgement based on a block error rate metric satisfying a threshold associated with a defined threshold criterion for a defined amount of time, that there is a connection to edge network equipment of a cellular network via which the first broadband cellular communications are conducted, or that a defined high mobility criterion is satisfied. That is, BLER can be high for a defined threshold value and time period; the UE can be located on cell edge; or the UE can be on high mobility.

After operation **1304**, process flow **1300** moves to operation **1306**.

Operation **1306** depicts conducting broadband cellular communications with the base station equipment according to the modified number of demodulation reference signal positions. In some examples, operation **1306** can be implemented in a similar manner as operation **1108** of FIG. **11**.

In some examples, the broadband cellular communications are second broadband cellular communications, modifying the number of demodulation reference signal positions comprises modifying the number of demodulation reference signal positions from a first number of demodulation reference signal positions to a second number of demodulation reference signal positions, and a second throughput of the second broadband cellular communications is less than a first throughput of a first broadband cellular communication that is conducted according to the first number of demodulation reference signal positions. That is, data throughput can be inversely proportional to a number of configured additional DMRS positions, where a larger number of additional DMRS symbols indicates a smaller data throughput.

After operation **1306**, process flow **1300** moves to **1308**, where process flow **1300** ends.

Example Operating Environment

In order to provide additional context for various embodiments described herein, FIG. **14** and the following discussion are intended to provide a brief, general description of a suitable computing environment **1400** in which the various embodiments of the embodiment described herein can be implemented.

For example, parts of computing environment **1400** can be used to implement one or more embodiments of dynamic additional DMRS configuration component **310** of FIGS. **3**A and **3**B; dynamic additional DMRS configuration component **410** of FIGS. **4**A and **4**B; dynamic additional DMRS configuration component **510** of FIGS. **5**A and **5**B; dynamic additional DMRS configuration component **610** of FIGS. **6**A and **6**B; gNB **702** and/or UE **704** of FIG. **7**; UE **902**, gNB **904**, and/or 5GC **906** of FIGS. **9**A and **9**B; and/or UE **1002**, gNB **1004**, and/or 5GC **1006** of FIGS. **10**A and **10**B.

In some examples, computing environment **1400** can implement one or more embodiments of the process flows of FIGS. **11**-**13** to facilitate dynamic additional DMRS configuration.

While the embodiments have been described above in the general context of computer-executable instructions that can run on one or more computers, those skilled in the art will recognize that the embodiments can be also implemented in combination with other program modules and/or as a combination of hardware and software.

Generally, program modules include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the various methods can be practiced with other computer system configurations, including single-processor or multiprocessor computer systems, minicomputers, mainframe computers, Internet of Things (IoT) devices, distributed computing systems, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

The illustrated embodiments of the embodiments herein can be also practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

Computing devices typically include a variety of media, which can include computer-readable storage media, machine-readable storage media, and/or communications media, which two terms are used herein differently from one another as follows. Computer-readable storage media or machine-readable storage media can be any available storage media that can be accessed by the computer and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media or machine-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable or machine-readable instructions, program modules, structured data or unstructured data.

Computer-readable storage media can include, but are not limited to, random access memory (RAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM), flash memory or other memory technology, compact disk read only memory (CD-ROM), digital versatile disk (DVD), Blu-ray disc (BD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, solid state drives or other solid state storage devices, or other tangible and/or non-transitory media which can be used to store desired information. In this regard, the terms "tangible" or "non-transitory" herein as applied to storage, memory or computer-readable media, are to be understood to exclude only propagating transitory signals per se as modifiers and do not relinquish rights to all standard storage, memory or computer-readable media that are not only propagating transitory signals per se.

Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

Communications media typically embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and includes any information delivery or transport media. The term "modulated data signal" or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media include wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

With reference again to FIG. **14**, the example environment **1400** for implementing various embodiments described herein includes a computer **1402**, the computer **1402** including a processing unit **1404**, a system memory **1406** and a system bus **1408**. The system bus **1408** couples system components including, but not limited to, the system memory **1406** to the processing unit **1404**. The processing unit **1404** can be any of various commercially available processors. Dual microprocessors and other multi-processor architectures can also be employed as the processing unit **1404**.

The system bus **1408** can be any of several types of bus structure that can further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and a local bus using any of a variety of commercially available bus architectures. The system memory **1406** includes ROM **1410** and RAM **1412**. A basic input/output system (BIOS) can be stored in a nonvolatile storage such as ROM, erasable programmable read only memory (EPROM), EEPROM, which BIOS contains the basic routines that help to transfer information between elements within the computer **1402**, such as during startup. The RAM **1412** can also include a high-speed RAM such as static RAM for caching data.

The computer **1402** further includes an internal hard disk drive (HDD) **1414** (e.g., EIDE, SATA), one or more external storage devices **1416** (e.g., a magnetic floppy disk drive (FDD) **1416**, a memory stick or flash drive reader, a memory card reader, etc.) and an optical disk drive **1420** (e.g., which can read or write from a CD-ROM disc, a DVD, a BD, etc.). While the internal HDD **1414** is illustrated as located within the computer **1402**, the internal HDD **1414** can also be configured for external use in a suitable chassis (not shown). Additionally, while not shown in environment **1400**, a solid state drive (SSD) could be used in addition to, or in place of, an HDD **1414**. The HDD **1414**, external storage device(s) **1416** and optical disk drive **1420** can be connected to the system bus **1408** by an HDD interface **1424**, an external storage interface **1426** and an optical drive interface **1428**, respectively. The interface **1424** for external drive implementations can include at least one or both of Universal Serial Bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394 interface technologies. Other external drive connection technologies are within contemplation of the embodiments described herein.

The drives and their associated computer-readable storage media provide nonvolatile storage of data, data structures, computer-executable instructions, and so forth. For the computer **1402**, the drives and storage media accommodate the storage of any data in a suitable digital format. Although the description of computer-readable storage media above refers to respective types of storage devices, it should be appreciated by those skilled in the art that other types of storage media which are readable by a computer, whether presently existing or developed in the future, could also be used in the example operating environment, and further, that any such storage media can contain computer-executable instructions for performing the methods described herein.

A number of program modules can be stored in the drives and RAM **1412**, including an operating system **1430**, one or more application programs **1432**, other program modules **1434** and program data **1436**. All or portions of the operating system, applications, modules, and/or data can also be cached in the RAM **1412**. The systems and methods described herein can be implemented utilizing various commercially available operating systems or combinations of operating systems.

Computer **1402** can optionally comprise emulation technologies. For example, a hypervisor (not shown) or other intermediary can emulate a hardware environment for operating system **1430**, and the emulated hardware can optionally be different from the hardware illustrated in FIG. **14**. In such an embodiment, operating system **1430** can comprise one virtual machine (VM) of multiple VMs hosted at computer **1402**. Furthermore, operating system **1430** can provide runtime environments, such as the Java runtime environment or the .NET framework, for applications **1432**. Runtime environments are consistent execution environments that allow applications **1432** to run on any operating system that includes the runtime environment. Similarly, operating system **1430** can support containers, and applications **1432** can be in the form of containers, which are lightweight, standalone, executable packages of software that include, e.g., code, runtime, system tools, system libraries and settings for an application.

Further, computer **1402** can be enable with a security module, such as a trusted processing module (TPM). For instance, with a TPM, boot components hash next in time boot components, and wait for a match of results to secured values, before loading a next boot component. This process can take place at any layer in the code execution stack of computer **1402**, e.g., applied at the application execution level or at the operating system (OS) kernel level, thereby enabling security at any level of code execution.

A user can enter commands and information into the computer **1402** through one or more wired/wireless input devices, e.g., a keyboard **1438**, a touch screen **1440**, and a pointing device, such as a mouse **1442**. Other input devices (not shown) can include a microphone, an infrared (IR) remote control, a radio frequency (RF) remote control, or other remote control, a joystick, a virtual reality controller and/or virtual reality headset, a game pad, a stylus pen, an image input device, e.g., camera(s), a gesture sensor input device, a vision movement sensor input device, an emotion or facial detection device, a biometric input device, e.g., fingerprint or iris scanner, or the like. These and other input devices are often connected to the processing unit **1404** through an input device interface **1444** that can be coupled to the system bus **1408**, but can be connected by other interfaces, such as a parallel port, an IEEE 1494 serial port, a game port, a USB port, an IR interface, a BLUETOOTH® interface, etc.

A monitor **1446** or other type of display device can be also connected to the system bus **1408** via an interface, such as a video adapter **1448**. In addition to the monitor **1446**, a computer typically includes other peripheral output devices (not shown), such as speakers, printers, etc.

The computer **1402** can operate in a networked environment using logical connections via wired and/or wireless communications to one or more remote computers, such as a remote computer(s) **1450**. The remote computer(s) **1450** can be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment appliance, a peer device or other common network node, and typically includes many or all of the elements described relative to the computer **1402**, although, for purposes of brevity, only a memory/storage device **1452** is illustrated. The logical connections depicted include wired/wireless connectivity to a local area network (LAN) **1454** and/or larger networks, e.g., a wide area network (WAN) **1456**. Such LAN and WAN networking environments are commonplace in offices and companies, and facilitate enterprise-wide computer networks, such as intranets, all of which can connect to a global communications network, e.g., the Internet.

When used in a LAN networking environment, the computer **1402** can be connected to the local network **1454** through a wired and/or wireless communication network interface or adapter **1458**. The adapter **1458** can facilitate wired or wireless communication to the LAN **1454**, which can also include a wireless access point (AP) disposed thereon for communicating with the adapter **1458** in a wireless mode.

When used in a WAN networking environment, the computer **1402** can include a modem **1460** or can be connected to a communications server on the WAN **1456** via other means for establishing communications over the WAN **1456**, such as by way of the Internet. The modem **1460**, which can be internal or external and a wired or wireless device, can be connected to the system bus **1408** via the input device interface **1444**. In a networked environment, program modules depicted relative to the computer **1402** or portions thereof, can be stored in the remote memory/storage device **1452**. It will be appreciated that the network connections shown are example and other means of establishing a communications link between the computers can be used.

When used in either a LAN or WAN networking environment, the computer **1402** can access cloud storage systems or other network-based storage systems in addition to, or in place of, external storage devices **1416** as described above. Generally, a connection between the computer **1402** and a cloud storage system can be established over a LAN **1454** or WAN **1456** e.g., by the adapter **1458** or modem **1460**, respectively. Upon connecting the computer **1402** to an associated cloud storage system, the external storage interface **1426** can, with the aid of the adapter **1458** and/or modem **1460**, manage storage provided by the cloud storage system as it would other types of external storage. For instance, the external storage interface **1426** can be configured to provide access to cloud storage sources as if those sources were physically connected to the computer **1402**.

The computer **1402** can be operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, store shelf, etc.), and telephone. This can include Wireless Fidelity (Wi-Fi) and BLUETOOTH® wireless technologies. Thus, the communication can be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

CONCLUSION

As it employed in the subject specification, the term "processor" can refer to substantially any computing processing unit or device comprising, but not limited to comprising, single-core processors; single-processors with software multithread execution capability; multi-core processors; multi-core processors with software multithread execution capability; multi-core processors with hardware multithread technology; parallel platforms; and parallel platforms with distributed shared memory in a single machine or multiple machines. Additionally, a processor can refer to an integrated circuit, a state machine, an application specific integrated circuit (ASIC), a digital signal processor (DSP), a programmable gate array (PGA) including a field programmable gate array (FPGA), a programmable logic controller (PLC), a complex programmable logic device (CPLD), a discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. Processors can exploit nano-scale architectures such as, but not limited to, molecular and quantum-dot based transistors, switches and gates, in order to optimize space usage or enhance performance of user equipment. A processor may also be implemented as a combination of computing processing units. One or more processors can be utilized in supporting a virtualized computing environment. The virtualized computing environment may support one or more virtual machines representing computers, servers, or other computing devices. In such virtualized virtual machines, components such as processors and storage devices may be virtualized or logically represented. For instance, when a processor executes instructions to perform "operations", this could include the processor performing the operations directly and/or facilitating, directing, or cooperating with another device or component to perform the operations.

In the subject specification, terms such as "datastore," data storage," "database," "cache," and substantially any other information storage component relevant to operation and functionality of a component, refer to "memory components," or entities embodied in a "memory" or components comprising the memory. It will be appreciated that the memory components, or computer-readable storage media, described herein can be either volatile memory or nonvolatile storage, or can include both volatile and nonvolatile storage. By way of illustration, and not limitation, nonvolatile storage can include ROM, programmable ROM (PROM), EPROM, EEPROM, or flash memory. Volatile memory can include RAM, which acts as external cache memory. By way of illustration and not limitation, RAM can be available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). Additionally, the disclosed memory components of systems or methods herein are intended to comprise, without being limited to comprising, these and any other suitable types of memory.

The illustrated embodiments of the disclosure can be practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

The systems and processes described above can be embodied within hardware, such as a single integrated circuit (IC) chip, multiple ICs, an ASIC, or the like. Further, the order in which some or all of the process blocks appear in each process should not be deemed limiting. Rather, it should be understood that some of the process blocks can be executed in a variety of orders that are not all of which may be explicitly illustrated herein.

As used in this application, the terms "component," "module," "system," "interface," "cluster," "server," "node," or the like are generally intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution or an entity related to an operational machine with one or more specific functionalities. For example, a component can be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, computer-executable instruction(s), a program, and/or a computer. By way of illustration, both an application running on a controller and the controller can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers. As another example, an interface can include input/output (I/O) components as well as associated processor, application, and/or application programming interface (API) components.

Further, the various embodiments can be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement one or more embodiments of the disclosed subject matter. An article of manufacture can encompass a computer program accessible from any computer-readable device or computer-readable storage/communications media. For example, computer readable storage media can include but are not limited to magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips . . .), optical discs (e.g., CD, DVD . . .), smart cards, and flash memory devices (e.g., card, stick, key drive . . .). Of course, those skilled in the art will recognize many modifications can be made to this configuration without departing from the scope or spirit of the various embodiments.

In addition, the word "example" or "exemplary" is used herein to mean serving as an example, instance, or illustration. Any embodiment or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments or designs. Rather, use of the word exemplary is intended to present concepts in a concrete fashion. As used in this application, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or." That is, unless specified otherwise, or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances. In addition, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form.

What has been described above includes examples of the present specification. It is, of course, not possible to describe every conceivable combination of components or methods for purposes of describing the present specification, but one of ordinary skill in the art may recognize that many further combinations and permutations of the present specification are possible. Accordingly, the present specification is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

What is claimed is:

1. A system, comprising:

at least one processor; and

at least one memory coupled to the at least one processor, comprising instructions that cause the at least one processor to perform operations comprising: configuring a first number of demodulation reference signal positions in radio resource control information as part of a connection setup with attaching to a base station that is configured to facilitate first broadband cellular communications;

as part of the attaching to the base station, receiving, from the base station, a message that comprises a first value that indicates that the base station is able to support modification of the first number of demodulation reference signal positions after the attaching to the base station, wherein the message is configured to comprise a second value that indicates that the base station is not able to support modification of the first number of demodulation reference signal positions after the attaching to the base station;

after attaching to the base station, receiving a medium access control control element message from the base station indicative of modifying the first number of demodulation reference signal positions to a second number of demodulation reference signal positions; and

conducting second broadband cellular communications with the base station according to the second number of demodulation reference signal positions, wherein a throughput of the second broadband cellular communications is determined as a function of a size of a transport block set based on the second number of demodulation reference signal positions.

2. The system of claim **1**, wherein the operations further comprise:

in response to receiving the medium access control control element message, sending, to the base station, a hybrid automatic repeat request message that acknowledges the medium access control control element message.

3. The system of claim **1**, wherein the medium access control control element message indicates triggering activation of demodulation reference signal positions.

4. The system of claim **1**, wherein the medium access control control element message indicates triggering deactivation of demodulation reference signal positions.

5. The system of claim **1**, wherein the operations further comprise:

as part of the attaching to the base station, receiving, from the base station, message further comprises a radio resource control setup message that indicates that the base station supports modification of the first number of demodulation reference signal positions after attaching to the base station.

6. The system of claim **5**, wherein an information element of the radio resource control setup message indicates that the base station supports the modification of the first number of demodulation reference signal positions after attaching to the base station.

7. The system of claim **1**, wherein the operations further comprise:

before receiving the medium access control control element message from the base station indicative of modifying the first number of demodulation reference signal positions, sending, to the base station, a user equipment capability message that indicates support for modification of the first number of demodulation reference signal positions after attaching to the base station.

8. The system of claim **7**, wherein an information element of the user equipment capability message indicates the support for the modification of the first number of demodulation reference signal positions after attaching to the base station.

9. The system of claim **1**, wherein the operations further comprise:

before receiving the message from the base station indicative of modifying the first number of demodulation reference signal positions, receiving the message further comprises a radio resource control reconfiguration message, and wherein an information element of the radio resource control reconfiguration message indicates that the base station supports modification of the first number of demodulation reference signal positions after attaching to the base station.

10. The system of claim **9**, wherein the information element comprises a physical downlink shared channel configuration information element of the radio resource control reconfiguration message that indicates that the base station supports the modification of the first number of demodulation reference signal positions in downlink communications.

11. The system of claim **9**, wherein the information element comprises a physical uplink shared channel configuration information element of the radio resource control reconfiguration message that indicates that the base station supports the modification of the first number of demodulation reference signal positions in uplink communications.

12. A method, comprising:

configuring, by a system comprising at least one processor, a first number of demodulation reference signal positions in radio resource control information as part of attaching to a base station that is configured to facilitate first broadband cellular communications;

as part of the attaching to the base station, receiving, by the system and from the base station, a message that comprises a first value that indicates that the base station is able to support modification of the first number of demodulation reference signal positions after the attaching to the base station, wherein the message is configured to comprise a second value that indicates that the base station is not able to support modification of the first number of demodulation reference signal positions after the attaching to the base station;

after the attaching to the base station that is configured to facilitate first broadband cellular communications, receiving, by the system comprising a processor, a medium access control control element message from the base station indicative of a first number of demodulation reference signal positions that was established as part of the attaching a connection setup being modified to a second number of demodulation reference signal positions; and

conducting, by the system, broadband cellular communications with the base station according to the second number of demodulation reference signal positions.

13. The method of claim **12**, wherein the second number of demodulation reference signal positions is configured for uplink communications of the broadband cellular communications, and wherein the receiving of the medium access control control element message from the base station is performed in response to sending uplink data to the base station.

14. The method of claim **13**, wherein the uplink data indicates that an uplink signal-to-noise ratio metric does not satisfy a threshold associated with a predetermined quality criterion for a defined amount of time, wherein a cyclic redundancy check that corresponds to the uplink data has failed or is failing, wherein the uplink data indicates that the system is connected to edge network equipment of a cellular network via which the broadband cellular communications are conducted, or wherein the uplink data indicates that the system satisfies a defined physical movement criterion.

15. A non-transitory computer-readable medium comprising instructions that, in response to execution, cause a system comprising at least one processor to perform operations, comprising:

configuring a first number of demodulation reference signal positions in radio resource control information as part of attaching to a base station that is configured to facilitate first broadband cellular communications;

as part of the attaching to the base station, receiving, from the base station, a message that comprises a first value that indicates that the base station is able to support modification of the first number of demodulation reference signal positions after the attaching to the base station, wherein the message is configured to comprise a second value that indicates that the base station is not able to support modification of the first number of demodulation reference signal positions after the attaching to the base station;

after the attaching to the base station that is configured to facilitate first broadband cellular communications, receiving a medium access control control element message from the base station equipment indicative of a modified number of demodulation reference signal positions that was established as part of a connection setup; and

conducting broadband cellular communications with the base station equipment according to the modified number of demodulation reference signal positions.

16. The non-transitory computer-readable medium of claim **15**, wherein modifying the number of demodulation reference signal positions is performed for downlink communications of the broadband cellular communications, and wherein the receiving of the medium access control control element message from the base station equipment is performed in response to sending hybrid automatic feedback that indicates failure or a channel quality indicator reporting metric to the base station equipment.

17. The non-transitory computer-readable medium of claim **16**, wherein the channel quality indicator reporting metric does not satisfy a threshold associated with a defined threshold criterion for a defined amount of time.

18. The non-transitory computer-readable medium of claim **16**, wherein the hybrid automatic feedback is being reported as a negative acknowledgement.

19. The non-transitory computer-readable medium of claim **18**, wherein the hybrid automatic feedback is being reported as the negative acknowledgement based on a block error rate metric satisfying a threshold associated with a defined threshold criterion for a defined amount of time, that there is a connection to edge network equipment of a cellular network via which the first broadband cellular communications are conducted, or that a defined high mobility criterion is satisfied.

20. The non-transitory computer-readable medium of claim **15**, wherein the broadband cellular communications are second broadband cellular communications, wherein modifying the number of demodulation reference signal positions comprises modifying the number of demodulation reference signal positions from a first number of demodulation reference signal positions to a second number of demodulation reference signal positions, and wherein a second throughput of the second broadband cellular communications is less than a first throughput of a first broadband cellular communication that is conducted according to the first number of demodulation reference signal positions.

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